REPORT
ON THE FLORA
OF THE
OTAY RANCH VERNAL POOLS, 1990-1991
SAN DIEGO COUNTY, CALIFORNIA

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ACKNOWLEDGMENTS

Field work contributing to the initial 1990 report (MBA 1990) was conducted primarily by Michael Brandman Associates (MBA) biologists Bonnie Hendricks, Fred Sproul, and Harold Wier, and RECON biologists Ellen Berryman, Karen Dunham, Marty Jacobsen, Anne Kreager, Cam Patterson, John Phillips, and Kirsten Winter. Robert Faught, consultant to MBA, also contributed to completion of the field work. Data analysis was completed primarily by Bonnie Hendricks, with data entry assistance from Robert Faught, Karen Bowling, and Michael Motta. Graphics were provided by Megan O'Neill with the assistance of Robert Faught and Bonnie Hendricks. The report was prepared by Bonnie Hendricks, Fred Sproul, and Harold A. Wier. Word processing was accomplished by Michael Motta and Marcia McRae.

Additional field work and updates requested by the Otay Ranch Task Force Biology Subcommittee were carried out by DUDEK biologists Harold Wier and John W. Brown in 1991. This final report including substantial new graphics was produced by DUDEK, with significant contributions by June S. Collins, Martie A. Clemons and Tonette S. Foster.

INTRODUCTION

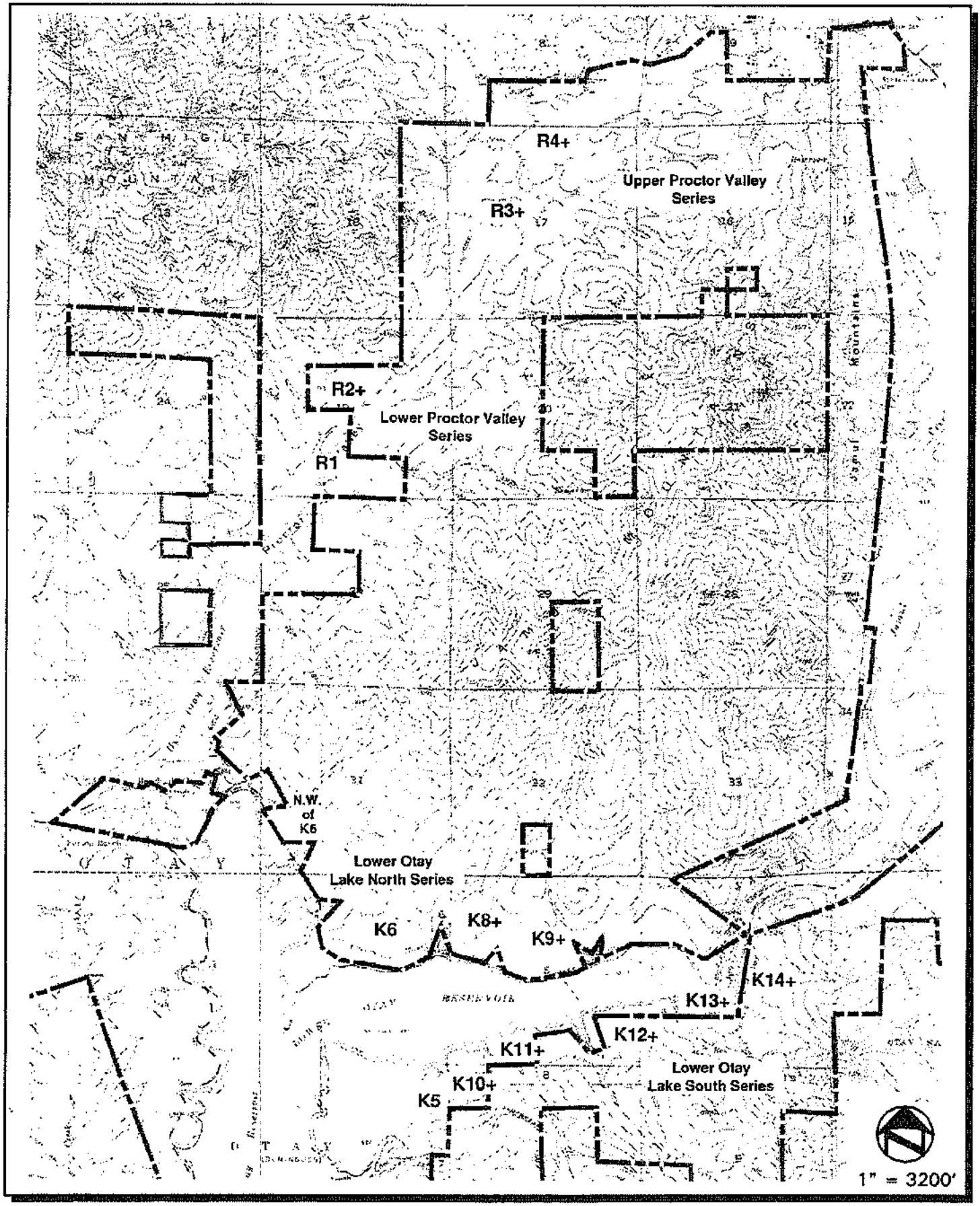
Otay Ranch is a 22,875-acre property located in southwestern San Diego County, California, east of the City of Chula Vista, and south of the community of Jamul. It includes part of Otay Mesa, Otay Valley, Proctor Valley, and the Jamul and San Ysidro Mountains (Figures 1 and 2). Otay Ranch is under the ownership of Baldwin Vista Associates, who engaged Michael Brandman Associates (MBA) and Dudek and Associates (DUDEK) to conduct intensive surveys of vernal pool areas on the Ranch in 1990 (MBA) and 1991 (DUDEK). RECON also was employed by Baldwin Vista Associates to assist with the 1990 field work and analysis.

The purpose of this report is to provide the following for incorporation into Phase 2 of the Resource Management Plan (RMP) for Otay Ranch: 1) a working definition of Otay Ranch vernal pools based on the literature and recent field work; 2) the distribution of vernal pool plant species, including sensitive species; and 3) the distribution of vernal pools on all of the mesas containing vernal pools and mima mound fields; 4) the location of areas that may be suitable for vernal pool restoration; and 5) the location of areas that are essential for conservation.

The Otay Ranch vernal pools occur on relatively flat land on all three of the major parcels. The largest concentrations of both pools and sensitive vernal pool species are found south of the Otay River on three large mesas; all of the intact vernal pool landscape within this area is proposed for inclusion within the Management Preserve proposed within the Phase 1 Resource Management Plan (RMP). Although no comprehensive inventory of vernal pools in the South Bay area has been published, it is obvious from earlier general studies (Bauder 1986) that the total numbers of vernal pools and occurrence of several sensitive vernal pool species is greatest on Otay Ranch, and that land development and off-road vehicle activity on Otay Mesa outside of Otay Ranch have reduced the number of pools and habitat for sensitive vernal pool species. Therefore, the Otay Mesa vernal pool habitat on Otay Ranch represents the area of greatest size, number of intact pools, greatest physical and biotic diversity, and best management potential.

Anticipated development on Otay Ranch and the surrounding area, with its attendant disturbance of biological resources, will likely result in greater pressure on the remaining scarce vernal pool resources in the South Bay area. This report also is intended to provide a current data base regarding the vernal pool resources on Otay Ranch and to identify locations and techniques for vernal pool restoration that may serve as potential mitigation for anticipated impacts to vernal pools, both within and outside Otay Ranch.

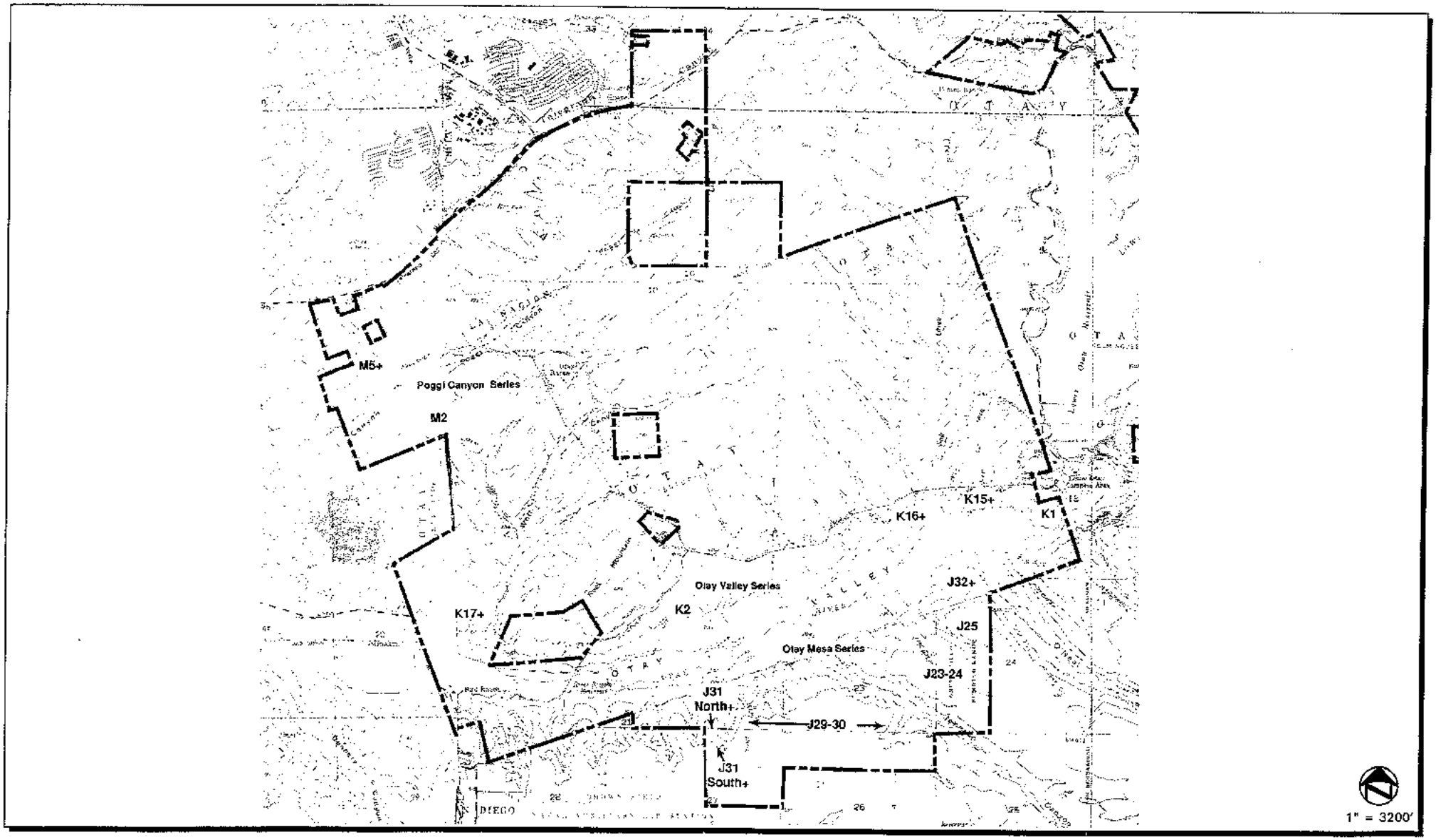
The status of biological resources in general and of vernal pools in particular on Otay Ranch has been investigated for many years by numerous biologists, botanists, and zoologists, each with diverse purposes and methods. During most of the 1970s and 1980s, the biological resources



Otay Ranch Vernal Pools

Proctor Valley & San Ysidro Mts. Parcels Vernal Pool Groups

FIGURE 1



Otay Ranch Vernal Pools

Otay Valley Parcel Vernal Pool Groups

FIGURE
2

of Otay Ranch largely were unknown primarily because it is a private holding operated as a cattle ranch. Data on the vernal pool areas of the ranch became public in 1978 and again in 1986 with the publication of the California Department of Fish and Game (CDFG) vernal pool reports for San Diego County (Beauchamp and Cass 1979, Bauder 1986). Additional unpublished research also was conducted (e.g., Timothy Cass, ca. 1983-86).

In the late 1980s, the former owner of the property, United Enterprises, Inc., hired the consultant firm ASI to conduct various reconnaissance-level biological studies, including vernal pool investigations (ASI 1987/1988). In 1988, Baldwin Vista Associates, attempting to process a Specific Plan through the City of San Diego for industrial development in the 400+ acre J 29-J 30 CDFG vernal pool area known as Otay Ranch Business Park, retained MBA and Dana R. Sanders, Ph.D., to conduct a general vernal pool survey and a limited-scope jurisdictional wetland delineation (MBA 1988). In spring 1989, Baldwin Vista Associates hired MBA and RECON to conduct general biological surveys of the entire Otay Ranch. MBA surveyed the 8,000-acre Proctor Valley-Jamul Mountains parcel (MBA 1989) while RECON surveyed the 9,500-acre Otay Valley and 5,300-acre San Ysidro Mountains parcels (RECON 1989). All parcels surveyed included vernal pools.

Baldwin Vista Associates hired MBA in late 1989 through summer 1990 to conduct comprehensive vernal pool mapping, hydrology and soils investigations and floral inventories on the Otay Ranch (MBA 1991). Following review of that report by members of the Otay Ranch Biology Subcommittee, Baldwin engaged DUDEK to conduct limited scope surveys of all pool areas in spring-summer 1991. These surveys were designed to test the reliability of the 1990 floral field work results, but did not address soils or hydrology. This report combines the 1990 and 1991 floral survey results, and discusses similarities and differences between the years.

WORKING DEFINITION OF VERNAL POOL HABITAT

The vernal pools of California are rare, seasonally moist, meadow-like habitats with plants and animals that are uniquely adapted to such aquatic conditions and survive in a "dormant" state for the remainder of the year. Many technical definitions for vernal pools have been formulated that describe the range of soil, geology, topography, soil chemistry, plant species, and other variable factors. These technical criteria are important parameters for differentiating vernal pools from other wetland habitats. Therefore, the following technical definition serves to distinguish similar but more widespread wetland habitats. "The vernal pool habitat may be defined loosely as a small depression, usually underlain by some subsurface layer which prohibits drainage into the lower soil profile, in which, during the rainy winter season, water may stand for periods of time sufficient to prohibit zonal vegetation from developing. The habitat is intermediate in duration of inundation between marshes (never or only rarely dry) and

most zonal communities (never or only rarely submerged). Seasonally standing water during the winter months, followed by total desiccation during the dry Mediterranean summer, are required for proper development of the vegetation of vernal pools" (Holland 1976).

Vernal pools have been considered as wetlands by numerous authors and many names have been applied to describe these seasonally wet habitats: vernal marshes, lakes, ponds or pools, non-persistent emergent wetlands, wet swales, wet springy pastures, vernally wet meadows, roadside ditches, hog-wallows, rain pools, winter pools, adobe depressions, and seasonal lakes (Holland 1976, Cowardin et al. 1979, Thorne 1984, Zedler 1987). The normal intervening summer drought, however, as well as longer term climatic fluctuations, make consistent determination of vernal pool habitats difficult. The Unified Federal Method for wetland delineation has been used with some caution to identify vernal pool habitat (Robert F. Holland, pers. comm.). The Federal Manual for Identifying and Delineating Jurisdictional Wetlands (WTI 1989) briefly addresses vernal pools as highly variable seasonal wetlands and recommends they be treated as "problem area wetlands." Wetlands that fall into this category are difficult to identify because field indicators of wetland soils, hydrology, or vegetation may be absent under normal environmental conditions (FICWD 1989). Thorne (1981), Bauder (pers. comm.) and P. Zedler (pers. comm.) regard the plant species as the most reliable indicators of vernal pool habitat. The proposed new Federal Manual covers vernal pools more extensively, classifying them as "special" or "problem" wetlands, subject to special procedures for delineation purposes.

In consideration of the above, and for the purposes of this report alone, the working definition of vernal pool habitat on Otay Ranch is as follows: "A vernal pool is a basin or shallow depression that supports at least one plant species ("indicator species") whose distribution in coastal California is completely or substantially restricted to vernal pool basins." These indicator species were identified by Zedler (1987) and shall be used to define vernal pools on Otay Ranch with the following exceptions: flowering quillwort (*Lilaea scilloides*), grass poly (*Lythrum hyssopifolium*), American pillwort (*Pilularia americana*), and slender woolly-heads (*Psilocarphus tenellus*). The authors feel that the former three species frequently are found in wetlands other than vernal pools and, therefore, are not by themselves reliable indicators of vernal pool habitat. *Psilocarphus tenellus* usually is restricted to shallow basins, some that contain other vernal pool and wetland species, but many that lack wetland hydrology and any other indicators of vernal pool or wetland habitat (pers. obs., Bonnie Hendricks, Fred Sproul; pers. comm., Ellen Bauder, Cam Patterson). The authors, therefore, have decided not to use the presence of this species alone as a criterion for defining a vernal pool. *Psilocarphus tenellus* is classified as a facultative wetland (FAC) species on the National List of Plant Species that Occur in Wetlands: California (Reed 1988); therefore, when it is dominant it can contribute to meeting the hydrophytic vegetation criterion of a jurisdictional wetland). Plant species found in basins and also associated with vernal pool habitat on the Otay Ranch are listed in Table 1.

TABLE 1

PLANT SPECIES FOUND IN BASINS ON THE OTAY RANCH

Vernal Pool Species[1]	Common Name	Wetland Status[3]	Abbrev.
Apiaceae			
•***Eryngium aristulatum***[2]	San Diego coyote-thistle	OBL	ErAr
Asteraceae			
Psilocarphus brevissimus	Woolly-marbles	OBL	PsBr
Psilocarphus tenellus	Slender woolly-heads	FAC	PsTe
Callitrichaceae			
Callitriche longipedunculata	Long-stalk water-starwort	OBL	CaLo
Crassulaceae			
Crassula aquatica	Water pigmy-weed	OBL	CrAq
Isoetaceae			
Isoetes orcuttii	Orcutt's quillwort	OBL	IsOr
Juncaginaceae			
Lilaea scilloides	Flowering quillwort	OBL	LiSc
Lamiaceae			
•***Pogogyne nudiuscula***	Otay mesa-mint	OBL	PoNu
Lythraceae			
**Lythrum hyssopifolia*	Grass poly	FACW	LyHy
Marsileaceae			
Pilularia americana	American pillwort	OBL	PiAm
Poaceae			
Deschampsia danthonioides	Annual hairgrass	FACW	DeDa
Phalaris lemmonii	Lemmon's canary grass	FACW	PhLe
Polemoniaceae			
Navarretia fossalis	Ditch navarretia		NaFo
Ranunculaceae			
Myosurus minimus var. ***apus***	Little mouse-tail	OBL	MyMi

Table 1 (Continued)

Other Wetland Species[4]	Common Name	Wetland Status	Abbrev.
Asteraceae			
Baccharis sarothroides	Desert broom	FAC	BaSa
* *Cotula coronopifolia*	African brass-buttons	FACW	CoCo
Isocoma veneta	Coastal goldenbush	FACW	IsVe
Boraginaceae			
Plagiobothys acanthocarpus	Adobe popcorn flower	OBL	PlAc
Brassicaceae			
* *Lepidium latipes*	Dwarf peppergrass	OBL	LeLa
Chenopodiaceae			
Atriplex semibaccata	Australian saltbrush	FAC	AtSe
Convolvulaecae			
Cressa truxillensis	Alkali weed	FACW	CrTr
Crassulaceae			
Crassula erecta	Sand pigmy-weed	FAC	CrEr
Cyperaceae			
Eleocharis macrostachya	Pale spike-sedge	OBL	ElMa
Iridaceae			
Sisirynchium bellum	California blue-eyed grass	FAC	SiBe
Juncaceae			
Juncus bufonius var. *halophilus*	Fasciculate toad-rush	FACW	JuBu
Juncus mexicanus	Mexican rush	FACW	JuMe
Malvaceae			
Malvella leprosa	Alkali mallow	FAC	MaLe
Ophioglossaceae			
Ophioglossum californicum	California adders-tongue fern	FACW	OpCa
Plantaginaceae			
Plantago bigelovii	Annual coast plantain	OBL	PlBi

Table 1 (Continued)

Other Wetland Species[4]	Common Name	Wetland Status	Abbrev.
Poaceae			
* *Lolium perenne*	English rye	FAC	LoPe
* *Monerma cylindrica*	Thintail	FACW	MoCy
* *Poa annua*	Annual bluegrass	FACW	PoAn
* *Polypogon monospeliensis*	Rabbitfoot grass	FACW+	PoMo
Sporobolus airoides	Alkali drop-seed	FAC	SpAr
Polygonaceae			
* *Rumex crispus*	Curly dock	FACW	RuCr
Primulaceae			
* *Anagallis arvensis*	Scarlet pimpernel	FAC	AnAr
Scrophalariaceae			
Veronica peregrina	Mexican speedwell	OBL	VePe
Tamaricaceae			
* *Tamarix* sp.	Tamarisk	FAC/ FACW	TaMa

Upland Species	Common Name	Wetland Status	Abbrev.
Alliaceae			
Allium praecox	Early onion	---	AlPr
Bloomeria crocea	Common golden-Stars	---	BlCr
Brodiaea jolonensis	Mesa brodiaea	---	BrJo
• *Muilla clevelandii*	Cleveland's golden-stars	---	MuCl
Muilla maritima	Rough muilla	---	MuMa
Asteraceae			
* *Anthemis cotula*	Mayweed	FACU	AnCo
Calycadenia tenella	Southern calycadenia	---	CaTe
* *Filago gallica*	Narrow-leaf filago	---	FiGa
Grindelia robusta	Big gumplant	FACU	GrRo

Table 1 (Continued)

Upland Species	Common Name	Wetland Status	Abbrev.
Gutierrezia bracteata	Broom matchweed	---	GuCa
* *Hedypnois cretica*	Crete hedypnois	---	HeCr
Hemizonia fasciculata	Fascicled tarweed	---	HeFa
Holocarpha virigata	Curving tarweed	---	HoVi
* *Hypochoeris glabra*	Smooth cat's-ear	---	HyGl
Lasthenia californica	Common goldfields	FACU	LaCa
Stylocline gnaphalioides	Everlasting nest-straw	---	StGn
Brassicaceae			
* *Brassica geniculata*	Shortpod mustard	---	BrGe
* *Brassica nigra*	Black mustard	---	BrNi
Lepidium nitidum	Shining peppergrass	---	LeNi
Cactaceae			
• *Ferocactus viridescens*	Coast barrel cactus	---	FeVi
Caryophyllaceae			
Silene laciniata	Southern pink	---	SiLa
* *Spergularia bocconii*	Buccone's sand-spurry	---	SpBo
Chenopodiaceae			
* *Salsola australis*	Russian thistle	FACU	SaAu
Crassulaceae			
• *Dudleya variegata*	San Diego hasseanthus	---	DuVa
Euphorbiaceae			
Eremocarpus setigerus	Dove weed	---	ErSe
Fabaceae			
* *Medicago polymorpha*	Bur-clover	---	MePo
Gentianaceae			
Centaurium venustum	Canchalagua	---	CeVe
Geraniaceae			
* *Erodium botrys*	Long-beak filaree	---	ErBo

Table 1 (Continued)

Upland Species	Common Name	Wetland Status	Abbrev.
Lamiaceae			
• *Salvia munzii*	Munz sage	---	SaMu
Trichostema lanceolatum	Vinegar weed	---	TrLa
Liliaceae			
Calochortus splendens	Splendid mariposa	---	CaSp
Chlorogalum parviflorum	Small-flower soap-plant	---	ChPa
• *Fritillaria biflora*	California chocolate lilly	---	FrBi
Malvaceae			
Sida leprosa	Alkali-mallow	---	SiLe
Plantaginaceae			
Plantago erecta	Dot-seed plantain	---	PlEr
Poaceae			
* *Avena barbata*	Slender oat	---	AvBa
* *Bromus mollis* (*B. hordeaceus*)	Soft chess	FACU	BrMo
* *Bromus rubens*	Red brome	Nl	BrRu
* *Gastridium ventricosum*	Nitgrass	FACU	GaVe
* *Lamarckia aurea*	Golden-top	---	LaAu
Hordeum depressum	Alkali barley	Nl	HoDe
* *Hordeum vulgare*	Cultivated barley	---	HoVu
* *Phalaris minor*	Little canary grass	---	PhMi
Stipa pulchra	Purple/nodding stipa	---	StPu
* *Vulpia myuros*	Foxtail fescue	FACU	VuMy
Polemoniaceae			
Linanthus liniflorus	Great basin linanthus	---	LiLi
Navarretia hamata	Hooked skunkweed	---	NaHa
Portulacaceae			
Calandrinia ciliata	Red maids	FACU	CaCi

Table 1 (Continued)

Upland Species	Common Name	Wetland Status	Abbrev.
Primulaceae			
Anagallis minimus	Common chaffweed	---	AnMi
Ranunculaceae			
Clematis pauciflora	Small-leaf virgin's bower	---	ClPa
Scrophulariaceae			
Orthocarpus densiflorus	Parish's owl's-clover	---	OrDe
Selaginellaceae			
• *Selaginella cinerascens*	Ashy spike-moss	---	SeCi
Solanaceae			
Datura wrightii	Jimsonweek/thorn-apple	---	DaWr
Lycium californicum	California desert thorn	---	LyCa

* plant species not native to California

• sensitive plant species

1. Vernal pool species - plants that occur within pool basins and are largely restricted to vernal pools, according to Zedler (1987).
2. **Boldface** vernal pool species - plants that the authors consider to be indicators of vernal pools.
3. Wetland Status (Reed 1988)

   Obligate Wetland (OBL). Occur almost always (estimated probability >99%) under natural conditions in wetlands.
   Facultative Wetland (FACW). Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in nonwetlands.
   Facultative (FAC). Equally likely to occur in wetlands or nonwetlands (estimated probability 34%-66%).
   Facultative Upland (FACU). usually occurs in nonwetlands (estimated probability 67%-99%), but occasionally found in wetlands (estimated probability 1%-33%).
   Obligate Upland (UPL). Occurs in wetlands in another region, but occurs almost always (estimated probability >99%) under natural conditions in nonwetlands in the region specified. If a species does not occur in wetlands in any region, it is not on the national List.
   No Indicator (NI). Species for which insufficient information was available to determine an indicator status.
4. Other wetland spp. - Non-vernal pool species that are on the National List of Plant Species that occur in Wetlands California (Reed 1988) as obligate wetland (OBL), facultative wetland (FACW), or facultative (FAC).

An area identified as a vernal pool using the above definition may not be identified as a pool under different definitions and jurisdictional guidelines such as the proposed (1991) revisions to the Federal Manual. Because of this, we do not offer this mapping of vernal pools as a formal delineation of isolated wetlands on Otay Ranch pursuant to federal authority under the Clean Water Act.

METHODS

The field methods were broken into three phases: 1) In the winter of 1990, MBA field biologists identified and tracked individual basins to monitor hydrologic conditions; 2) in the spring and summer of 1990, MBA and RECON biologists worked together to obtain the distributions of vernal pool species in individual basins on the entire Otay Ranch; 3) in the spring-summer of 1991, DUDEK conducted floral surveys in a random sample within all pool groups except K 5, K 10+, K 11+, and K 13+ (All of these pool groups are offsite and were included in the 1990 study only because of the now-retracted proposal for "South Dam Road" that may have affected vernal pools in this area.).

Hydrology

There were four rainstorms that brought more than 0.5 inch of rain each during the winter of 1990 (Table 2). Basins with standing water or saturated soil were staked and numbered. Many additional basins that appeared to be wetter than the surrounding basins, even if the soil was not saturated, also were staked and numbered. Evidence of saturated soils was recorded at the surface and between 1 to 10 inches below the surface, usually between 2 to 4 inches. Soil saturation was detected by the presence of free water which appeared after squeezing a sample of soil between the fingers or as a glistening sheen on the soil surface. Water depth was measured with a ruler in the deepest portion (not including hoof prints) of a basin.

The following number ratings were used in the field to describe the degree of saturation:

Saturation Codes:

0	=	soil dry or slightly damp below surface
1	=	damp below surface
2	=	wet but unsaturated below surface
3	=	just barely saturated below surface
4	=	saturated below surface
5	=	saturated on surface
6	=	standing water
*	=	no standing water (other data not taken)

TABLE 2
PRECIPITATION AND TEMPERATURES FROM SEPTEMBER 1989 TO FEBRUARY 1990 AT BROWN FIELD ON OTAY MESA, SAN DIEGO COUNTY, CALIFORNIA

	Temperature		
	Maximum	Minimum	Precipitation
16 September 89	83°	68°	Trace
17 September 89	73°	64°	0.18"
19 September 89	68°	54°	0.09"
21 October 89	70°	59°	0.08"
22 October 89	79°	62°	0.14"
25 October 89	66°	56°	0.16"
26 November 89	64°	53°	0.10"
28 December 89	61°	53°	0.10"
19 December 89	59°	43°	0.50"
03 January 90	60°	40°	0.01"
14 January 90	60°	54°	0.62"
15 January 90	59°	45°	0.11"
16 January 90	57°	44°	0.18"
17 January 90	54°	44°	0.64"
18 January 90	55°	35°	0.03"
31 January 90	58°	47°	0.59"
01 February 90	57°	47°	0.04"
04 February 90	54°	40°	0.27"
18 February 90	57°	48°	0.63"
19 February 90	55°	34°	0.16"

Basins were judged to have wetland hydrology if they had standing water or saturated soil at or below the surface 7 days or more after the last rain (see Wetland Delineation section of this report for the federal definition). In several cases surveys were done on the sixth day after the first rain. Basins that had standing water on the sixth day after a rain were classified as having wetland hydrology. The survey at J 30 on 24 January was 6 days after a very light rain (0.03" on 18 January) and 7 days after a heavier rain (0.64" on 17 January). Therefore, that survey was treated as a seventh day survey and all basins with saturated soil were classified as having wetland hydrology.

Flora

Floral taxonomy used in this report follows Munz (1974). Common plant names, where not available from Munz (1974) are taken from Beauchamp (1986), Abrams (1923) or Smith and Berg (1988). Sensitive vernal pool plant species previously recorded or potentially present on the Otay Ranch were identified through a literature search and personal communication using the following sources: U.S. Fish and Wildlife Service (USFWS 1987), California Department of Fish and Game (CDFG 1987), California Natural Diversity Data Base (CNDDB 1989), Fred T. Sproul, (ASI 1987, 1988), Timothy L. Cass (1988), MBA (1988, 1989), RECON (1989), Beauchamp and Cass (1978), and Bauder (1986).

1990 Surveys

Each basin in areas of potential vernal pool habitat was observed and scanned for vernal pool indicator species. Floral information was recorded for all basins that possessed vernal pool indicator species (see Table 3) and for all basins that were included in the hydrology surveys. Basins with indicator species also were staked and numbered if they had not been staked already during the hydrology surveys.

The dominant species, vernal pool species, and other associated plant species were recorded for each basin that was staked. Dominants and vernal pool species were always recorded, whereas other wetland plants and upland species were not consistently noted, especially if they were uncommon or hard to detect. Abundance of species in a basin was estimated subjectively according to the following categories: dominant, common, uncommon, and rare. Occasionally a species was recorded as present without assigning an abundance rating to it. The ratings were determined subjectively by each surveyor but were loosely defined as follows: dominant species in a basin were defined as those that made up 20 percent or more of the vegetative cover or the most abundant species that exceeded 50 percent of the cover. A species was labeled common if it made up approximately 10 to 20 percent cover, uncommon if it made up 1 to 10 percent cover, and rare if it was less than 1 percent cover.

Survey limitations: Given the large number of basins present on the Ranch and the difficulty in observing the small and sometimes cryptic vernal pool plants, it is obvious that some basins probably were overlooked and that indicator species were overlooked or not detected in some basins that were sampled. Based on the thoroughness of the survey, the use of aerial photography, and the results of previous surveys, we feel that the number of basins possibly overlooked is on the order of less than 1% of the total found. The percentage of surveyed basins that actually had vernal pool indicator species but these species were not detected by us is probably less than 10%, again based on the thoroughness of the survey and comparable results between 1990 and 1991.

Some vernal pool species were not visible during part or all of the floral survey. Water pygmy-weed (*Crassula aquatica*) and long-stalk water-starwort (*Callitriche longipedunculata*) generally were dried up and unidentifiable by the time the floral surveys were begun in late April 1990. They were recorded in several areas during the hydrology and basin staking surveys in January and February 1990, but notes specifically on the flora were not kept routinely during that time. Otay mesa-mint (*Pogogyne nudiuscula*) was visible during most of the survey but became increasingly difficult to detect after early June 1990 when most individuals had finished blooming. Annual hairgrass (*Deschampsia danthonioides*) was easier to detect after mid-May 1990 when more individuals began blooming. It may have been present in higher frequency than it was recorded, as was probably the case with *Crassula* and *Callitriche* (Table 3).

Eleven field biologists were involved in the 1990 floral surveys and because much of the data collection included some subjectivity, some error was inevitable. The majority of field work, however, was done by six biologists, Karen Dunham, Robert Faught, Bonnie Hendricks, Marty Jacobson, Fred Sproul, and Harold Wier. These biologists frequently consulted with each other in the field, sometimes working in pairs, to standardize their criteria for choosing species abundance ratings and pool boundaries and to ensure a sharp search image for species that were difficult to find.

1991 Surveys

Dudek & Associates biologists John W. Brown and Harold A. Wier surveyed a random a sample of previously surveyed vernal pools for flora during the late spring and early summer 1991. Survey dates were 12, 13, 20 and 26 June and 9 and 10 July 1991. The same methods used in 1990 floral surveys were used in 1991, except only a small sample of pools was surveyed. In addition, all of the southern portion of J 29-30 and J 31 South+ were systematically surveyed for sensitive species that had been reported earlier by Timothy L. Cass. The purposes of the 1991 survey were to test the reliability of the 1990 results, and to survey two areas that were suspected to contain sensitive species not found in 1990: K6 and the southern part of J29-30 and J31 South+.

TABLE 3
PERCENT FREQUENCY OF VERNAL POOLS WITH EACH VERNAL POOL SPECIES AND WETLAND SPECIES (1990-1991)

	OTAY MESA					OTAY VALLEY				LOWER OTAY LAKE SOUTH				
	J-29 &J30	J31 S+	J31 N+	J23 & J24	J25	J32+	K1	K15 & K16	K17+	K5	K10+	K12+	K13	K14+
Vernal Pool Species														
Callichtriche longipedunculata	0.6			3.2	2.0	66.6				28.6	44.4	25.0	50.0	
Crassula aquatica	0.6			4.5	1.3	33.3	28.6		50.0					
Deschampsia danthonioides	3.5			0.6	1.3	33.3	14.3					50.0		
Eryngium aristulatum ssp. parishii	62.4	83.3		5.3	7.3					71.4				
Isoetes orcuttii	0.6			0.2										
Lilaea scilloides	1.8			0.2		33.3								
Lythrum hyssopifolia	2.4			0.9	2.0	100.0	28.6	20.0						
Myosurus minimus var. *apus*														
Navarretia fossalis														
Phalaris lemmonii				16.4	12.0	33.3								
Pilularis americana	1.2													
Pogogyne nudiuscula	10.0			4.7	36.4									
Psilocarphus brevissimus	58.2	16.6	100.0	95.1	87.4	66.6	100.0	100.0	100.0	100.0	77.7	100.0	100.0	100.0
Psilocarphus tenellus	0.6			6.0	1.3			*		*	22.2	75.0		
Other Wetland Species														
Anagallis arvensis								*						
Atriplex semibaccata	10.6	33.3	*	1.7										
Baccharis sarothroides								20.0						
Cotula coronopifolia						33.3								
Cressa truxillensis	3.5	50.0												
Eleocharis macrostachya	0.6			0.2	2.6	66.6				14.3				
Isocoma veneta	5.9			1.3	14.0									
Juncus bufonius var. *halophilus*	1.2		*	0.6		100.0	28.6	20.0						
Lepidium latipes	*													
Malvella leprosa	0.6	33.3												
Monerma cylindrica				9.4	2.0									
Ophioglossum californicum												*		

Table 3 (Continued)

	OTAY MESA					OTAY VALLEY				LOWER OTAY LAKE SOUTH				
	J-29 &J30	J31 S+	J31 N+	J23 & J24	J25	J32+	K1	K15 & K16	K17+	K5	K10+	K12+	K13	K14+
Plagiobothrys cf. acanthocarpus	4.1	*	*	6.6	9.3	33.3		60.0		*		50.0		
Plantago bigelovii							14.3							
Poa annua							14.3			14.3				
Polypogon monospeliensis						66.6		*						
Rumex crispus						33.3	14.3	*						
Sisirynchium bellum	16.5	50.0		13.7	56.3									
Sporobolus airoides				0.2										
Tamarix sp.				0.7										
Veronica peregrina							28.6							

* Indicates species located in basins not identified as vernal pool.

	LOWER OTAY LAKE NORTH				LOWER PROCTOR VALLEY		UPPER PROCTOR VALLEY		POGGI CANYON	
	Mesa NW of K6 (Reiser)	K6	K8+	K9+	R1	R2+	R3+	R4+	M2	M5+
Vernal Pool Species										
Callitriche longipedunculata		33.3	18.2		14.3	44.4		100.0		100.0
Crassula aquatica						11.1				
Deschampsia danthonioides		33.3	72.7		14.3	88.8	33.3			
Eryngium aristulatum ssp. *parishii*							100.0			
Isoetes orcuttii										
Lilaea scilloides										
Lythrum hyssopifolia		66.6	9.1				66.6		40.0	
Myosurus minimus var. *apus*		33.3								
Phalaris lemmanii			72.7							
Pilularia americana										
Pogogyne nudiuscula										
Psilocarphus brevissimus		66.6	90.9		85.7	55.5	66.6		100.0	100.0
Psilocarphus tenellus				100.0						

Table 3 (Continued)

	LOWER OTAY LAKE NORTH				LOWER PROCTOR VALLEY		UPPER PROCTOR VALLEY		POGGI CANYON	
	Mesa NW of K6 (Reiser)	K6	K8+	K9+	R1	R2+	R3+	R4+	M2	M5+
Other Wetland Species										
Anagallis arvensis										
Atriplex semibaccata										
Baccharis sarothroides					*					
Cotula coronopifolia										
Cressa truxillensis										
Eleocharis macrostachya		33.3					66.6			
Isocoma veneta										
Juncus bufonius var. *halophilus*			9.1	100.0						
Lepidium latipes										
Malvella leprosa										
Monerma cylindrica			27.3							
Ophioglossum californicum	*				*	*				
Plagiobothrys cf. acanthocarpus		33.3	45.5	100.0					80.0	*
Plantago bigelovii							33.3			
Poa annua										
Polypogon monospeliensis										
Rumex crispus									20.0	
Sisirynchium bellum	*	33.3	27.3				33.3			
Sporobolus airoides										
Tamarix sp.										
Veronica peregrina										

* Indicates species located in basins not identified as vernal pool.

Fauna

Although the endemic flora of California's vernal pools is well known (Holland 1976; Thorne 1981), there is no such parallel understanding of the associated fauna (Eng, Belk, and Eriksen 1990). Among this unique fauna are western spadefoot toad (*Scaphiopus hammondi*) - a California Department of Fish and Game "species of special concern" - and a group of small aquatic invertebrates known as fairy shrimp (Order Anostraca). A number of terrestrial invertebrates frequent vernal pools, but few of these animals are restricted to this habitat.

Fairy shrimp are one of the most characteristic inhabitants of vernal pools, and in the appropriate environment they may be extremely abundant. They hatch in the spring soon after pools fill with rainwater runoff. Development from larvae into reproductive adults may be accomplished in less than a week (Pennack 1978). Adults mate soon after maturation, and females lay their eggs - up to 200 (Simovich *et al.* 1990). The eggs settle into the bottom mud of the pool where they remain until the rainy season of the following year, or until the next season when pools have aquatic conditions for a sufficient period. Eggs are extremely resistant and can withstand considerable desiccation. For some species, eggs may remain viable for up to 15 years (Moore 1979) and may be transported between pools in the gut of birds (Proctor 1964, Proctor *et al.* 1967).

With over 17 species of fairy shrimp recorded from California (Eng, Belk, and Eriksen 1990), this state has the highest species richness of any area in the United States. Several species in the genus *Branchinecta* currently are being considered for "Species of Special Concern" status by the California Department of Fish and Game; the United State Fish and Wildlife Service has received a petition to list the Riverside fairy shrimp (*Streptocephalus wootoni*) as threatened or endangered pursuant to the Endangered Species Act of 1973.

Because of their small size, ephemeral adult stage, and narrow range of habitats, fairy shrimp previously have been overlooked or disregarded by most biologists involved in resource management. However, these animals are a conspicuous, endemic component in the community ecology of vernal pool habitat.

A reconnaissance-level survey for fairy shrimp was conducted in the J25 and J30 pools by Dr. Marie Simovich in 1990 (Appendix C). Samples from a very few pools were taken, including samples of live shrimp and mud samples from pools that did not fill naturally in 1990 due to low rainfall. The mud samples were hydrated in the laboratory to determine the presence or absence of shrimp. In addition to the field work, current literature regarding fairy shrimp distributions was reviewed.

A number of terrestrial invertebrates, primarily insects, are associated with vernal pools. These animals utilize vernal pool vegetation as nectar sources, perching substrates, or larval food plants. Although directed surveys were not conducted for these faunal elements, local experts were consulted and the general literature was reviewed. At least one federal Category 2 candidate butterfly, the quino checkerspot (*Euphydryas editha quino*), previously was recorded from vernal pool areas on Otay Ranch (Dudek & Associates 1991). the checkerspot was last collected on Otay Mesa in 1982.

Basin Size and Disturbance

The size of each basin was determined by first delimiting the boundaries of the vernal pool or basin habitat. This was ultimately a subjective decision but was based on identifying the elevation at which the greatest visible change occurred in plant abundance (e.g., fascicled tarweed (*Hemizonia fasciculata*) was lush in basin bottoms in 1990 and quickly became sparser with increasing elevation) and species composition (presence of vernal pool species, usually woolly-marbles (*Psilocarphus brevissimus*), helped to define the boundaries). Each basin included in the survey was measured by pacing the maximum length (minor axis) and the estimated maximum width (major axis), assuming the basin was approximately elliptical. If the basin was approximately circular or triangular, the radius or base and height respectively were measured and the shape noted. If the basin's shape was radically different from the above shapes (e.g. L-shaped), the size was approximated by visualizing the shape as two or more ellipses stuck together and measuring the dimensions of each ellipse. Sizes for circular and triangular basins were calculated using their respective formulas, and size for approximately oval basins was calculated by using the following formula for the area of an ellipse: Π (radius of minor axis) (radius of major axis).

If disturbance of some kind was considered a significant feature of the basin, the type of disturbance was recorded (cattle tracks, roads, vehicle tracks, scraping, discing, bomb craters, grazing, gopher activity, ditching/excavation, mowing, plowing, and dumping of trash).

Mapping

Each basin that was staked during the 1990 hydrology or floral surveys was mapped. The J 23-24, J 25, lower Proctor Valley, K 6, and K 8+ areas were mapped on 1" = 40' scale topographic maps with 0.5-foot contour intervals and 0.1-foot spot elevations; flying and photogrammetry were done by Don Read on December 15, 1989, and survey control was done by the McIntire Group. The J 29-30 and Space Station areas were mapped on 1" = 100' topographic maps with 0.5 foot contour intervals and 0.1 foot spot elevations, and were flown on March 6, 1989 by San-lo Aerial Surveys. The Lower Otay Lake-South areas were first mapped on aerial photographs flown by Aerial Foto-bank and then transferred to 1"=200' scale

County of San Diego topographic maps with 5 foot contour intervals. Otay Valley vernal pools also were mapped on aerial photographs and on the McIntire Group 1" = 40' topographic maps when available. Poggi Canyon vernal pools were mapped on 1" = 200' scale color aerial photographs then transferred to 1" = 1,000' scale topographic maps with 20-foot contours derived from the 7.5 minute USGS Otay Mesa quadrangle. Upper Proctor Valley vernal pools were mapped directly on 1" = 1000' scale topographic maps with 20 foot contour intervals derived from 7.5 minute USGS topographic maps (Jamul Mountains, Otay Mesa, and Imperial Beach quadrangles). Because at the time 40 scale aerial topography and/or color aerial photography were ordered, we were not aware of vernal pools in Upper Proctor Valley, part of Otay Valley and Lower Otay Lake South, these materials were not available for use and the best available substitution were used.

1991 surveys utilized the same maps and aerial photographs.

The Aerial Foto-bank maps and San-Lo maps allowed a field investigator to locate him or herself precisely anywhere on the map. Individual pools and mounds were evident as were small features such as local depressions within the pools, pool interconnections, and disturbance caused by scraping and bombing. By itself, the 200' scale County topography is useful only for generalized pool area mapping. But in concert with color aerials and roads which are evident on the 200' scale maps, reasonably precise mapping is possible.

RESULTS AND DISCUSSION

Otay Mesa

Otay Mesa lies on the U.S.-Mexican border, east of San Ysidro, west of the San Ysidro Mountains, and south of Otay Valley (Figures 1 and 2). The three largest groups of vernal pools within the Otay Ranch property are found on Otay Mesa, J 29-30; J 23-24; and J 25. (Vernal pool group codes follow Bauder 1986; new codes assigned in this report are followed by +, e.g., J 32+). Otay Mesa vernal pools occur on marine terraces with mima mound topography that have developed gray clay soils. The soils are from the Stockpen series and are classified as gravelly clay loam with 0 to 2 percent slopes (USDA 1973).

The predominant vegetation type within the Otay Mesa vernal pool groups is disturbed valley needlegrass grassland or annual grassland with a sparse scattering of coastal sage scrub. The dominant species include wild oats (*Avena barbata*), long-beak filaree (*Erodium botrys*), fascicled tarweed (*Hemizonia fasciculatum*), purple needlegrass (*Stipa pulchra*), flat-top buckwheat (*Eriogonum fasciculatum*), coastal sagebrush (*Artemisia californica*), coast barrel cactus (*Ferocactus viridescens*), and coast goldenbush (*Isocoma veneta*).

Plant species that occurred as dominants most frequently within vernal pool basins on Otay Mesa were fascicled tarweed, followed by English ryegrass (*Lolium perenne*), *Erodium botrys*, and *Avena barbata*. The dominant plants occurring most frequently in basins that lacked vernal pool indicator species were the same as for basins with vernal pool indicator species. A few upland species (e.g., blue-eyed grass (*Sisyrinchium bellum*) and *Stipa pulchra*), however, replaced the vernal pool species (e.g., *Eryngium aristulatum* var. *parishii* and *Psilocarphus brevissimus*) as dominants in the non-vernal pool basins.

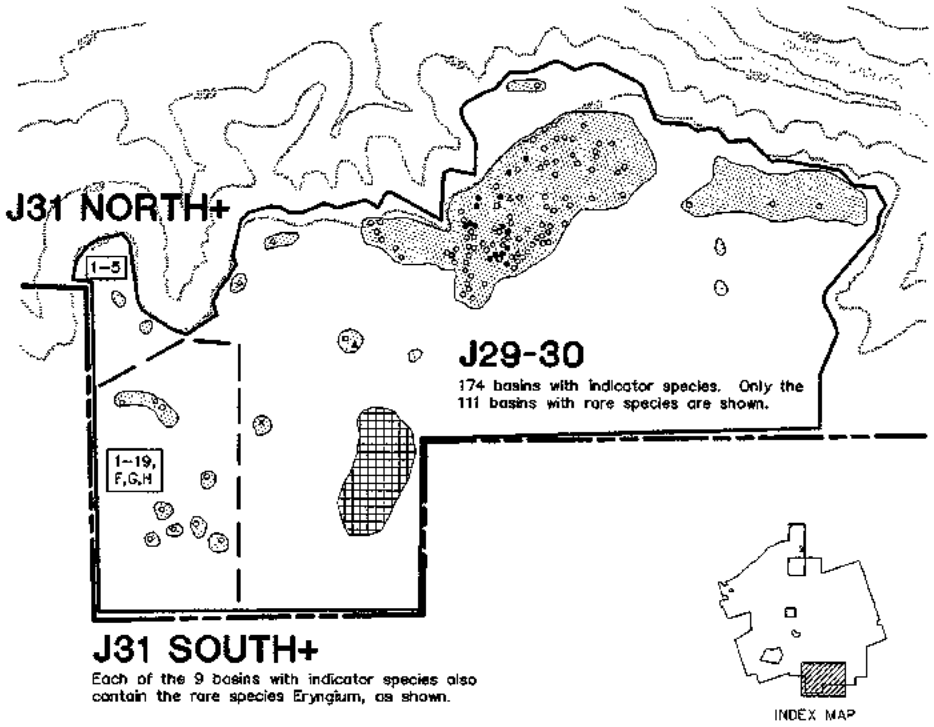
J 29-30, J 31 South+ (Space Station), and J 31 North+

The northern part of the J 29-30 mesa has large intact mima mounds and the densest grouping of vernal pools, whereas the southern part of the mesa has been plowed and graded in the past and lacks large mima mounds and has only a few scattered vernal pools (Figure 3 [map pocket] and Figure 5). Just west of J 29 is an area that is enclosed by a chain link fence and is leased to the Navy and used as a space surveillance station. This area is continuous with the J 29-30 mesa, has been graded and plowed in the past and is mowed regularly; it has been given a new vernal pool group code: J 31 South+. Just north and outside of the Space Station is a lobe of the same mesa extending toward Otay Valley; this area has undisturbed mima mound topography and has been labeled J 31 North+.

Many basins that were staked and tracked during the hydrology survey appeared moister than surrounding basins but did not necessarily hold water for more than several hours in 1990. On J 29-30, a total of 323 basins was staked during the 1990 field work, 170 of which were identified as vernal pools by the presence of at least one vernal pool indicator species (Table 4). Of the vernal pools identified, four were impacted by a dirt road. Cattle trampling, which causes deep prints in the clay soil when moist, was common on the mesa. The Space Station (J 31 South+) had six basins with vernal pool indicator species present in 1990 (a total of 22 basins was staked and numbered). In 1991, an additional 5 basins containing at least one indicator species were found. The lobe north of the Space Station (J 31 North+) had two basins with vernal pool indicators in 1990 (a total of 5 basins were staked). Because sampling was concentrated on the main parts of the mesa, this area was not resurveyed in 1991.

Eleven vernal pool species were found within J 29-30 in the winter and spring of 1990, and two additional species - ditch navarretia (*Navarretia fossalis*) and American pillwort (*Pilularia americana*) - were found in 1991 (Table 3). *Eryngium aristulatum* and *Psilocarphus brevissimus*) occurred much more frequently than the other nine vernal pool species (Table 3).

During field work in June 1991, 37 previously-surveyed vernal pools were re-surveyed for flora. Where *Lolium perenne* was a dominant species in 1990, it was very often dominant in 1991,



Legend

- Area surveyed for vernal pools
- Area of vernal pool habitat with indicator species
- *Lepidium latipes*
- ◦ Individual vernal pool with *Eryngium aristulatum*
- △ Individual vernal pool with *Pogogyne nudiuscula*
- × Individual vernal pool with *Navarretia fossalis*
- • Individual vernal pool with both *Eryngium* and *Pogogyne*
- ▲ Individual vernal pool with both *Eryngium* and *Navarretia*
- **K6** Vernal pool group code
- 18–21 I.D. numbers of all basins staked

1" = 1000'

Otay Ranch Vernal Pools

Otay Mesa Vernal Pool Group: J29-30, J31 South+, J31 North+

FIGURE 5

TABLE 4. SUMMARY OF VERNAL POOL DATA

Pool Group	Total Basins Staked	Road Basins Staked	Basins w/ V.P. Indicators	Road Basins w/ V.P. Indicators	Basins w/ Pogogyne	Basins w/ Eryngium	Basins w/ Pogogyne and Eryngium	Basins w/ Myosurus	Basins w/ Navarretia
Otay Mesa									
J29-30	323	13	170	4	17	106	14	0	2
J31 South+	22	0	6	0	0	5	0	0	0
J31 North+	5	0	2	0	0	0	0	0	0
J 23-24	617	32	531	19	25	28	1	0	0
J 25	177	16	151	11	55	11	3	0	0
SUBTOTAL	1,144	61	860	34	97	150	18	0	2
Otay Valley									
J 32+	4	3	3	2	0	0	0	0	0
K 1	7	1	7		0	0	0	0	0
K 15+	10	5	4	1	0	0	0	0	0
K 16+	1	1	1	1	0	0	0	0	0
K 17+	8	2	2	1	0	0	0	0	0
SUBTOTAL	30	12	17	5	0	0	0	0	0
Lower Otay Lake South									
K 5	15	1	7	0	0	5	0	0	0
K 10+	15	0	9	0	0	0	0	0	0
K 12+	7	0	4	0	0	0	0	0	0
K 13+	5	2	2	2	0	0	0	0	0
K 14+	6	0	1	0	0	0	0	0	0
SUBTOTAL	48	3	23	2	0	5	0	0	0
Lower Otay Lake North									
Reiser	10	0	0	0	0	0	0	0	0
K 6	12	0	3	0	0	0	0	1	0
K 8+	14	2	11	1	0	0	0	0	0
K 9+	9	5	0	0	0	0	0	0	0
SUBTOTAL	45	7	14	1	0	0	0	1	0
Poggi Canyon									
M 2	0	6	5	0	0	0	0	0	0
M 5+	5	8	1	0	0	0	0	0	0
SUBTOTAL	5	14	6	0	0	0	0	0	0
Lower Proctor Valley									
R 1	19	2	14	1	0	0	0	0	0
R 2+	9	0	9	0	0	0	0	0	0
SUBTOTAL	28	2	23	1	0	0	0	0	0
Upper Proctor Valley									
R 3+	3	0	3	0	0	3	0	0	0
R 4+	3	0	1	0	0	0	0	0	0
SUBTOTAL	6	0	4	0	0	3	0	0	0

however *Erodium botrys* and *Hemizonia fasciculata* were often not dominant in 1991 where they had been in 1990. *Hemizonia*, which was a distinctive and abundant pool bottom species in 1990 and was sparse and stunted on the mounds between pools, was common and vigorous on the mounds in 1991. In 7 pools where *Psilocarphus brevissimus* was recorded in 1990, its cover value increased in 1 pool (14 percent), remained the same in 2 pools (28 percent), and decreased (1) or was absent (3) in 4 pools (57 percent) in 1991. Among the 37 pools resurveyed, *Psilocarphus brevissimus* was found in 4 pools where it was not recorded in 1990. In 19 pools where *Eryngium* was recorded in 1990, its cover rating remained the same in 6 pools (32 percent), increased in one pool (0.5 percent) and decreased in 12 pools (63 percent). *Eryngium* was absent in four of these latter 12 pools in 1991. In two pools where *Pogogyne* was recorded in 1990, its cover rating decreased in one and increased in one in 1991.

In both 1990 and 1991, *Eryngium aristulatum* and Otay mesa-mint (*Pogogyne nudiuscula*), both state-listed endangered species, were common in the north central area of J 29-30. During the two years combined, *Eryngium* was present in a total of 108 vernal pools (62 percent of all vernal pools; two additional pools with *Eryngium* were found in 1991), *Pogogyne* was present in 17 pools (10 percent of all pools; no new *Pogogyne* pools were found), and the two rare plants occurred together in 14 pools (8 percent of all pools). *Navarretia fossalis* was found in two pools (0.1 percent of all pools) in 1991 in the disturbed area south of the main concentration of vernal pools in J 29-30, and co-occurred with *Eryngium* in both pools. *Eryngium* also was present in the Space Station area in five out of the six vernal pools identified (83 percent). *Pogogyne* was not present in the Space Station area in either 1990 or 1991.

Two additional rare vernal pool species, California Orcutt grass (*Orcuttia californica*), and little mousetail (*Myosurus minimus* var. *apus*) were found on this mesa by Timothy Cass in 1979 (pers. comm. 1988). *Myosurus* was reported from the southwestern portion of J 29-30 and from the Space Station area where the mounded topography has been obliterated by grading and plowing. *Orcuttia* was reported from an artificial cattle stock pond at the northwestern edge of J 29-30. None of these species were found during the spring 1990 and 1991 surveys, or by Bauder in 1986, MBA in 1988, or RECON in 1989.

Within the J30 complex, two species of fairy shrimp were observed: *Branchinecta "sandiegensis"* (an undescribed species) and *Stretocephalus wootoni*. *Branchinecta "sandiegensis"* is a newly discovered species that has been found only on the San Diego Mesa complex, including Tecate, Mexico. Because of its exceedingly limited distribution, it is likely to be considered a sensitive species. *Streptocephalus wootoni*, the Riverside fairy shrimp, is known from five pools in Riverside County (Skunk Hollow area) and two pools in San Diego County (Otay Ranch and NAS Miramar). Although not observed on the J 29-30 complex, *Branchinecta lindahli* is a possible resident. It is a widespread species of the western United States and is the most common fairy shrimp in California.

During survey work in late spring 1990, Comstock's fritillary butterfly (*Speyeria callippe comstocki*) was abundant in the J 29-30 area. This species typically occurs in native grasslands where the larvae utilize *Viola* species (Violaceae) as larval hosts. During survey work during the summer 1991, a variety of insects were observed in the J 20-30 area including three species of butterflies - painted lady (*Vanessa cardui*), checkered white (*Ponita protodice*), and Behr's metalmark (*Apodemia mormo virgulti*) - and numerous pollinators such as bee flies (Bombyliidae), flower flies (Syrphidae), bees (Apidae), and spider wasps (Pompilidae). Also observed were snowy tree crickets (*Oecanthus* sp.; Gryllidae), grasshoppers (Acridiae), praying mantids (Mantidae), darkling ground beetles (*Eleodes* sp.; Tenebrionidae), and dragonflies (Libellulidae).

J 23-24

J 23-24 is a large mesa extending to the west of the California State Correctional Facility and includes the largest acreage and number of vernal pools on the Otay Ranch. The Mima mound topography is generally undisturbed with the exception of a dirt road along the boundary with the prison (this road was graded again between summer 1990 and spring 1991) and a scraped area running east to west across the mesa (evident in aerial photographs taken in the 1960's). Disturbance from cattle trampling is abundant. Water runoff from a nursery operation at the prison threatens to alter the vernal pool flora of a few basins on the eastern boundary with the prison. Many bomb craters and bomb debris are scattered across the mesa on mounds and in basins.

Five-hundred thirty-three basins were found to have vernal pool indicator species and, therefore, are considered to be vernal pools (532 in 1990; one pool was added in 1991; Figures 3 and 6; Table 4). Nineteen of the vernal pools (4 percent) lie within the dirt road.

Eleven vernal pool species were present on J 23-24. Lemmon's canary grass (*Phalaris lemmonii*) was the only species not found on the J 29-30 mesa (J 29-30 also had three vernal pool species not found on J 23-24, *Pilularia, Navarretia fossalis* and *Lepidium latipes*). On J 23-34 *Psilocarphus brevissimus* occurred in 95 percent of the vernal pools, *Phalaris lemmonnii* was in 16 percent of pools, and all other vernal pool species had a frequency of less than six percent (Table 4). The frequencies of certain small, ephemeral, non-sensitive species (e.g. *Callitriche*, *Crassula*, and *Deschampsia*) non-sensitive indicators probably are artificially low because the plants were difficult to detect on most of the later-season survey dates.

During field work in June 1991, 35 previously-surveyed vernal pools were re-surveyed for flora. In 25 pools where *Psilocarphus brevissimus* was recorded in 1990, it was present in 22 pools in 1991 (88 percent). Its cover value increased in 5 pools (20 percent), remained the same in 10 pools (40 percent), and decreased (7 pools) or was absent (3 pools) in 10 pools (40 percent).

In 9 pools where *Pogogyne* was recorded in 1990, it was present in only 5 pools (56 percent) in 1991. Its cover value did not increase in any of the pools, remained the same in 2 (22 percent) and decreased (3 pools) or was absent (4 pools) in 7 pools (78 percent). No new locations for *Pogogyne* were found in 1991 on J 25. In one pool where *Eryngium* was recorded in 1990, its cover value remained the same in 1991. One new location for *Eryngium* was discovered, a pool where it was a dominant plant.

Both state endangered vernal pool species, *Eryngium* and *Pogogyne* were present on J 23-24. *Eryngium* occurred in 28 of the vernal pools (five percent) and *Pogogyne* was found in 24 pools (5 percent). Only one pool had both species.

J 25

The J 25 mesa is bounded by Otay Valley on the northwest, O'Neal Canyon on the north, and a smaller canyon that separates J 23-24 to the south (Figure 3). This mesa also was used as a test bombing range in the 1940s. Many basins were made deeper by the explosions that formed craters. A dirt road, cattle tracks, and a large circular scraped area (origin unknown but present prior to the 1960s according to Aerial-Fotobank photographs) are additional disturbances on this mesa top.

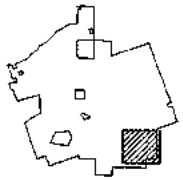
A total of 151 basins had vernal pool indicator species in 1990 (177 basins were staked; Figure 6). Eleven of the vernal pools (seven percent) lie within the dirt road, and 53 (35 percent) previously existing vernal pools appeared to be deepened by the impact of bombs. Explosions within basins made localized deeper holes of a few feet in diameter in some cases. Explosions on mounds may have pushed soil into some of the pool basins.

Nine vernal pool species were present, all of which also were found on J 23-24. The rare *Pogogyne* is more abundant here than anywhere else on the Ranch; it was present in 55 (36 percent) of the vernal pools. *Eryngium* was found in 11 (7 percent) of the vernal pools, and the two species occurred together in only three basins. *Pogogyne* occurred in 22 bomb-deepened vernal pools out of the 55 total pools in which it was present. Check against 1991 data.

During field work in June 1991, 17 previously surveyed vernal pools were re-surveyed for flora. In 16 pools where *Psilocarphus brevissimus* was recorded in 1990, it was recorded in 16 pools in 1991 (94 percent). In 6 pools (35 percent) its cover rating remained the same, it was rated as more abundant in 4 (23 percent) and less abundant in 5 (29 percent). In 12 pools where Pogogyne was recorded in 1990, it was present in all of the pools in 1991. In 4 pools (33 percent) its cover remained the same, it was rated more abundant in none and less abundant in 8 (66 percent). It was found in one new location also.

J25
151 basins with indicator species. Only the 59 basins with rare species are shown.

J23-24
533 basins with indicator species. Only the 45 basins with rare species are shown.



INDEX MAP

Legend

- Area surveyed for vernal pools
- Area of vernal pool habitat with indicator species
- ◦ Individual vernal pool with *Eryngium aristulatum*
- ▵ Individual vernal pool with *Pogogyne nudiuscula*
- • Individual vernal pool with both *Eryngium* and *Pogogyne*
- **K6** Vernal pool group code
- 18–21 I.D. numbers of all basins staked

1" = 1000'

Otay Ranch Vernal Pools
Otay Mesa Vernal Pool Group: J23-24, J25

FIGURE
6

The wetland delineation process revealed 13 basins to have wetland hydrology, seven basins to have hydrophytic vegetation, and two basins to have both characteristics. These two basins also were found to have *Psilocarphus brevissimus* and other vernal pool indicators.

Within the J 25 complex, one species of fairy shrimp was observed - *Branchinecta "sandiegensis."* Although neither *Branchinecta lindahli* nor *Streptocephalus wootoni* was observed, the habitat appears appropriate for the occurrence of both.

Otay Valley

Otay Valley is situated north of Otay Mesa. It drains westward from the watersheds of both Upper and Lower Otay Reservoirs, originating at the Lower Otay Dam. Pools occur on several small, disjunct, elevated mesas along the north rim of the valley (Figure 3) that are remnants of the same marine terrace that comprises Otay Mesa (USDA 1973). These vernal pool groups (Figures 7, 8 and 9) are numbered J 32 +, K 1, K 15+, K 16+, K 2, and K 17+. The soils associated with the first three (eastern) pool groups are of the Huerhuero series; the latter two (western) pool groups have soils of the Olivenhain series. Pool groups K 16+, K 2, and K 17+ were disced and seeded in about 1989 but formerly supported scattered shrubs of coastal sage scrub and plants common to valley needlegrass grassland.

Some vernal pools occur at the toe of the bluffs on the south side of Otay Valley on Olivenhain and Huerhuero soils (J 32+). Most of the valley bottom historically has been farmed and utilized for surface materials mining; therefore, pools also may have occurred more extensively on Salinas soils or in Riverwash alluvium.

Vernal pools were identified in all areas except the historic K 2 group (Bauder 1986). About half of the pools in the Otay Valley area are highly disturbed by roads, vehicle tracks, or plowing. Three pools were present in the J 32+ valley bottom area, two that are road pools and one that is a relatively large, pristine pool. Seven vernal pools were identified in the K 1 group (six on the mesa and one in the valley), four pools on the two adjoining K 15+ mesas, one highly disturbed road pool on the K 16+ mesa, and two pools disturbed by plowing on the K 17+ mesa. In general, pools in this area are much more scattered and at lower density than those on Otay Mesa.

The flora of vernal pool basins in the Otay Valley groups includes eight wetland species not found on Otay Mesa (Table 3). The vernal pool species, however, are the same as on Otay Mesa except the Otay Valley groups lack all of the rare species found on the Ranch and two other species limited to longer water duration pools, Orcutt's quillwort (*Isoetes orcutti*) and *Pilularia*. The dominant species within basins most frequently included *Hemizonia fasciculata* and *Erodium botrys* with *Psilocarphus brevissimus* dominating in several basins on the K 1 mesa

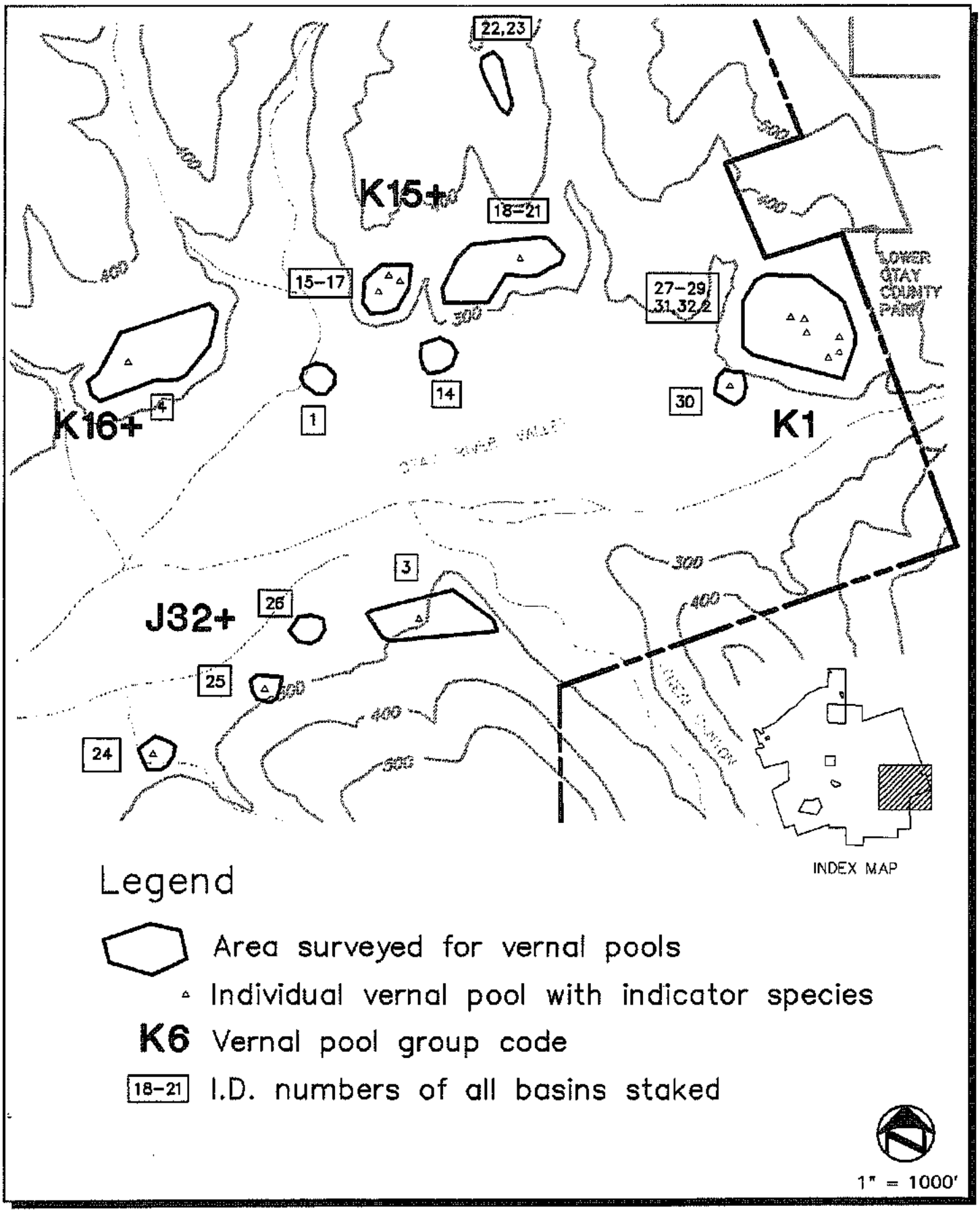
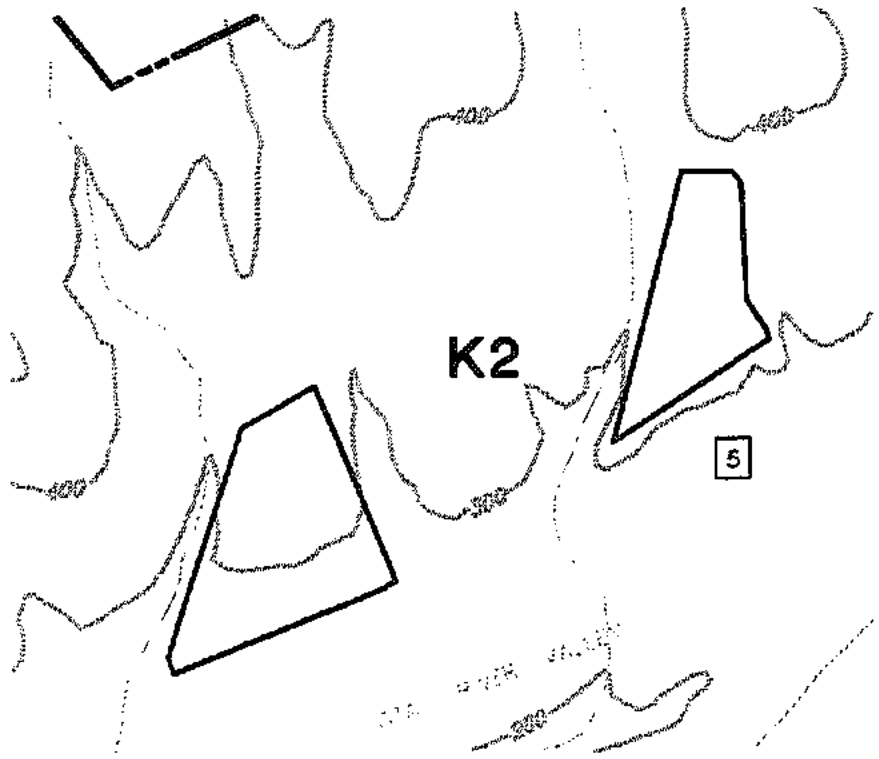
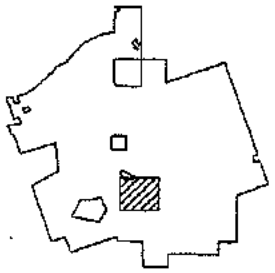


FIGURE 7

Otay Ranch Vernal Pools

Otay Valley Vernal Pool Group: J32+, K1, K15+, K16+





INDEX MAP

Legend

Area surveyed for vernal pools

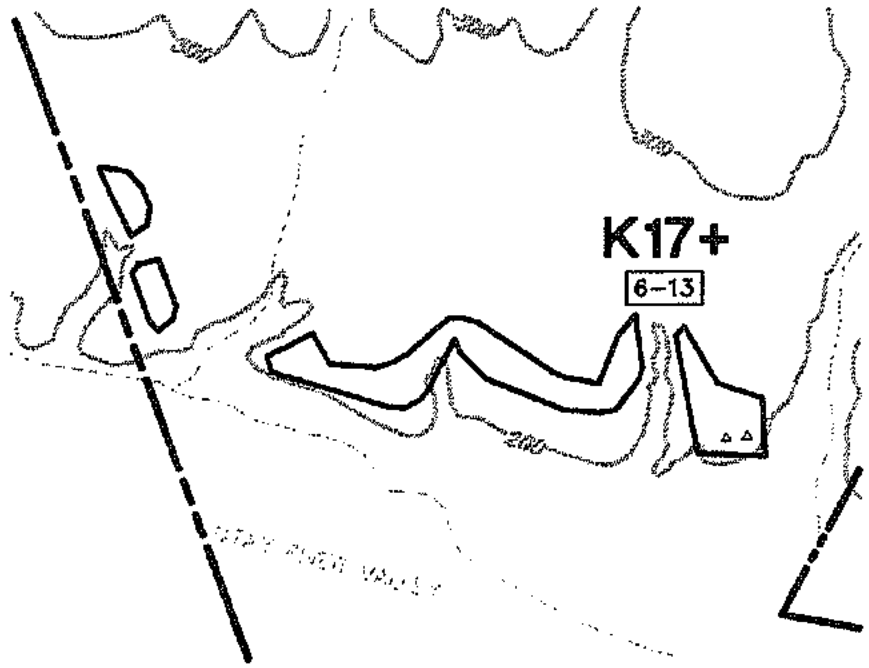
K6 Vernal pool group code

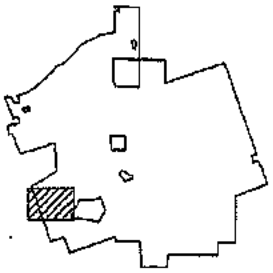
18–21 I.D. numbers of all basins staked

1" = 1000'

FIGURE 8

Otay Ranch Vernal Pools
Otay Valley Vernal Pool Group: K2





INDEX MAP

Legend

- Area surveyed for vernal pools
- ▵ Individual vernal pool with indicator species
- **K6** Vernal pool group code
- 18-21 I.D. numbers of all basins staked

1" = 1000'

FIGURE 9

Otay Ranch Vernal Pools
Otay Valley Vernal Pool Group: K17+

and in the valley at J 32+. Cultivated barley (*Hordeum leporinum*) was a codominant in basins on the recently cultivated K 17+ mesa.

Poggi Canyon

Poggi Canyon lies south of Telegraph Canyon and north of Otay Valley (Figure 3). It empties to the west, draining some low rolling clay hills south of Telegraph Canyon and north of Wolf Canyon. Vernal pools (Figure 10) in this area are located on ridges north of Poggi Canyon (pool group M 5+), and immediately south (M 2). Both of these vernal pool series occur on remnants of highly dissected alluvial marine terraces on soils of the Olivenhain series.

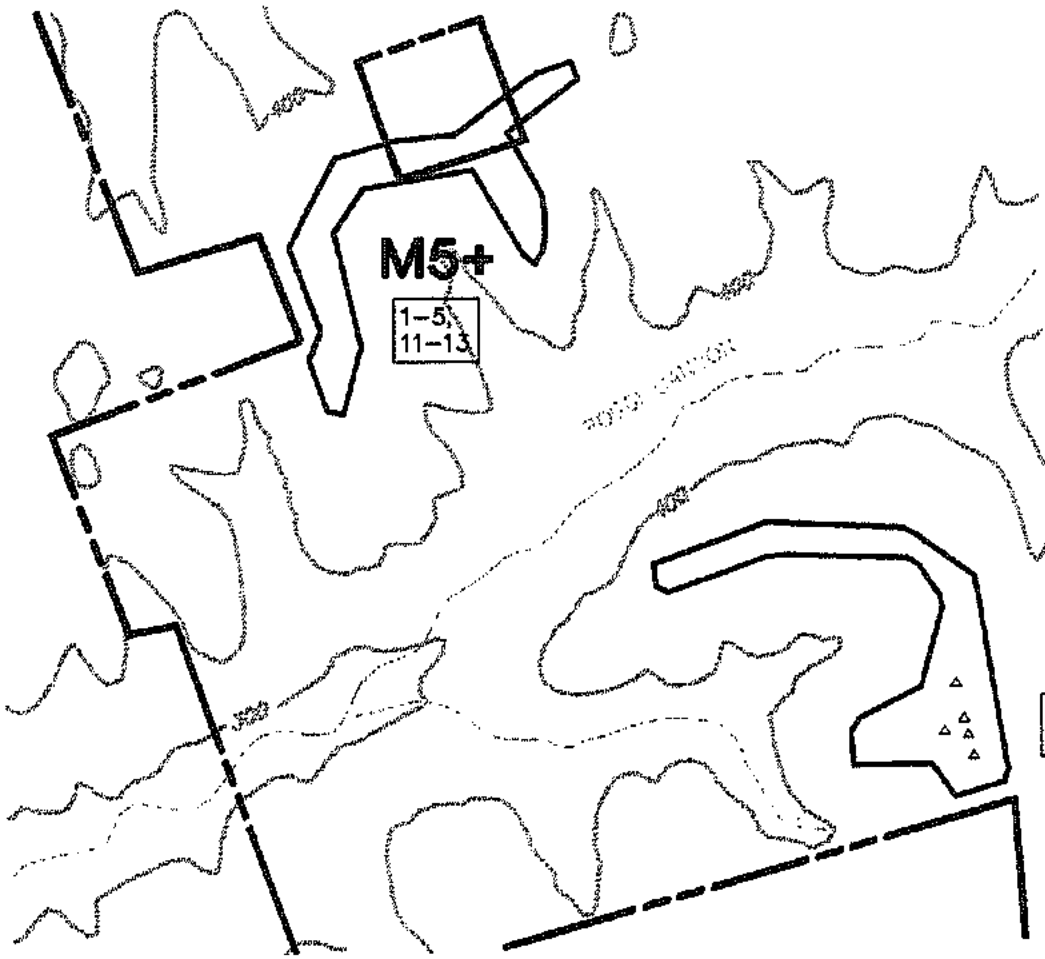
These ridges were brushed and disced (circa spring 1989) such that very little vegetation was evident in 1990 or 1991. The dominant vegetation type had been coastal sage scrub, with perennial grasses and some vernal pool flora in the basins.

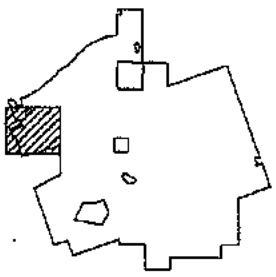
One vernal pool was identified on the ridge north of Poggi Canyon (M 5+) in 1990, and 3 disturbed vernal pools with *Psilocarphus brevissimus* were found there in 1991. Five vernal pools were found on the south side (M 2) in 1990, and 1 disturbed pool with *Psilocarphus brevissimus* was found there in 1991. In 1990, the dominant plants within basins were *Hemizonia fasciculata* and *Erodium botrys* with red maids (*Calandrinia ciliata*) also dominating in M 5+ and foxtail fescue (*Vulpia myuros*) dominating in M 2. In 1991, the dominants were generally the same however *Bromus rubens* was a dominant in two pools of M5+, and *Bromus hordeaceus* was a dominant in the M2 pool. In both areas, the soils were distinctly gray and water marks were present on rocks. Evidence of hydrology was seen in all pools. The only vernal pool species present were *Psilocarphus brevissimus*, long-stalk water-starwort *Callitriche longipedunculata*, grass poly *Lythrum hyssopifolia*, cf. adobe popcorn flower (*Plagiobothrys* cf. *acanthocarpus*) and slender wooly-heads (*Psilocarphus tenellus*).

Lower Otay Lake - South

A series of low terraces that support vernal pools occur south of the east arm of Lower Otay Reservoir (Figure 4 [map pocket]). These terraces are mostly continuous although they have been numbered in six separate groups (K 5, K 10+, K 11+, K 12+, K 13+, and K 14+). These pool groups are also on alluvial marine terrace deposits with Olivenhain and Redding soils.

These pools occur among perennial grasslands that support San Diego needlegrass (*Stipa diegoensis*) and scattered shrubs typical of coastal sage scrub. The dominant surrounding vegetation, however, is chaparral composed of chamise (*Adenostoma fasciculatum*), Munz's sage (*Salvia munzii*), and some Ramona lilac (*Ceanothus tomentosus*).





INDEX MAP

Legend

- Area surveyed for vernal pools
- ▵ Individual vernal pool with indicator species
- **K6** Vernal pool group code
- [18–21] I.D. numbers of all basins staked

1" = 1000'

FIGURE 10

Otay Ranch Vernal Pools
Poggi Canyon Vernal Pool Group: M2, M5+

The vernal pools (Figures 11 & 12) in most pool groups are relatively undisturbed including seven vernal pools on the east lobe of K 5, four pools in the K 12+ groups, and one pool in K 14+. K 13+ consists of two vernal pools that are bisected by the main dirt road. Vehicle tracks are a disturbance to four out of the five pools in the K 10+ group.

The only rare vernal pool species was San Diego button-celery which was present in the K 5 pool group. The dominant species within the vernal pool basins typically included fascicled tarweed, long-beak filaree, and a number of other plants depending on the pool group. San Diego button-celery was codominant in several pools in K 5; woolly-marbles was codominant in some pools at all areas except K 14+ where early onion (*Allium praecox*) was codominant. The K 12+ area was unique in that several other native vernal pool fringe species were dominant, including common goldfields (*Lasthenia californica*), sand pygmy-weed (*Crassula erecta*), dot-seed plantain (*Plantago erecta*), and ashy spike-moss (*Selaginella cinerascens*).

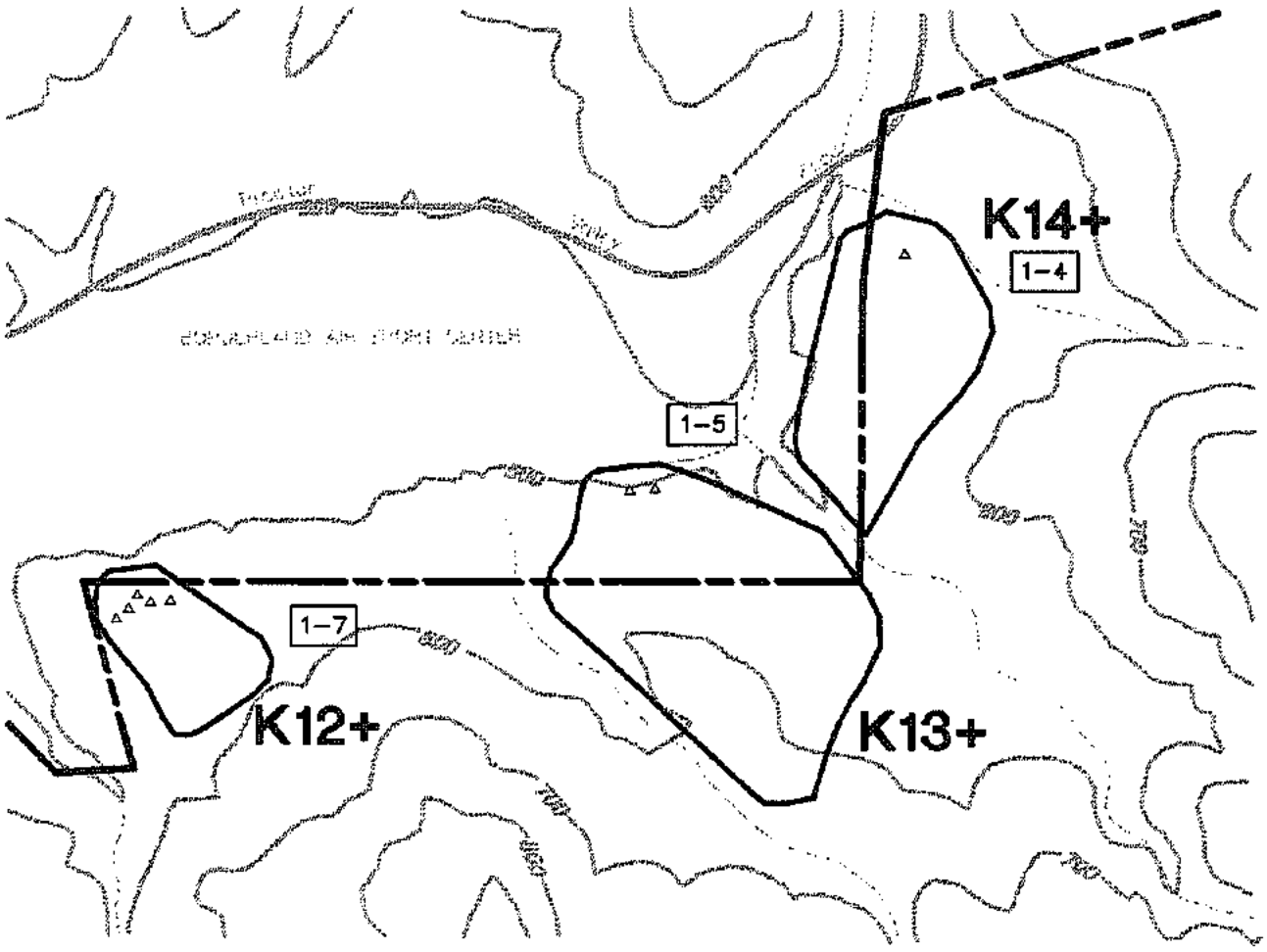
The greatest diversity in vernal pool species among the Lower Otay Lake - south groups was encountered in K 5 and K 12, which had four species each: *Psilocarphus brevissimus*, *Callitriche* and *Psilocarphus tenellus*. In K 5, *Eryngium* was present, whereas K 12+ had *Deschampsia*.

It was determined that hydrophytic vegetation existed only in one basin in the K 5 area in 1990. This basin was dominated by *Eryngium*, *Psilocarphus brevissimus* and *Hemizonia fasciculata*. Wetland hydrology was present in two basins on K 5, five basins on K 10+, and two basins on K 13+. Five (55 percent) of the basins with wetland hydrology had vernal pool species and two of those were road pools.

Lower Otay Lake - North

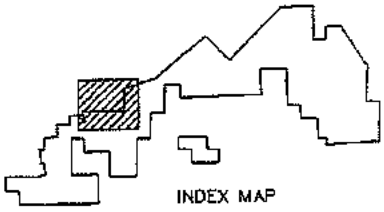
A series of disjunct terraces is divided by the eastern arm of Lower Otay Lake (Figure 4). Otay Lakes Road forms a southern border to the terraces north of the lake (numbered K 6, K 8+, K 9+, and a mesa northwest of K 6--Reiser Mesa). These small mesas are derived from the same marine terrace substrate as Otay Mesa, featuring soils of the Olivenhain series with mima mound topography.

Because mesas K 6 and K 8+ have been burned recently and heavily grazed, much of the original shrub cover is depleted. The predominant plants are native bunchgrasses and forbs such as purple needlegrass (*Stipa pulchra*), goldenbush (*Isocoma veneta*) and introduced annual grasses. The mesa numbered K 9+ is mostly dominated by chamise chaparral, although the southern rim has large grassy openings with perennial grasses and some elements of coastal sage scrub.



Legend

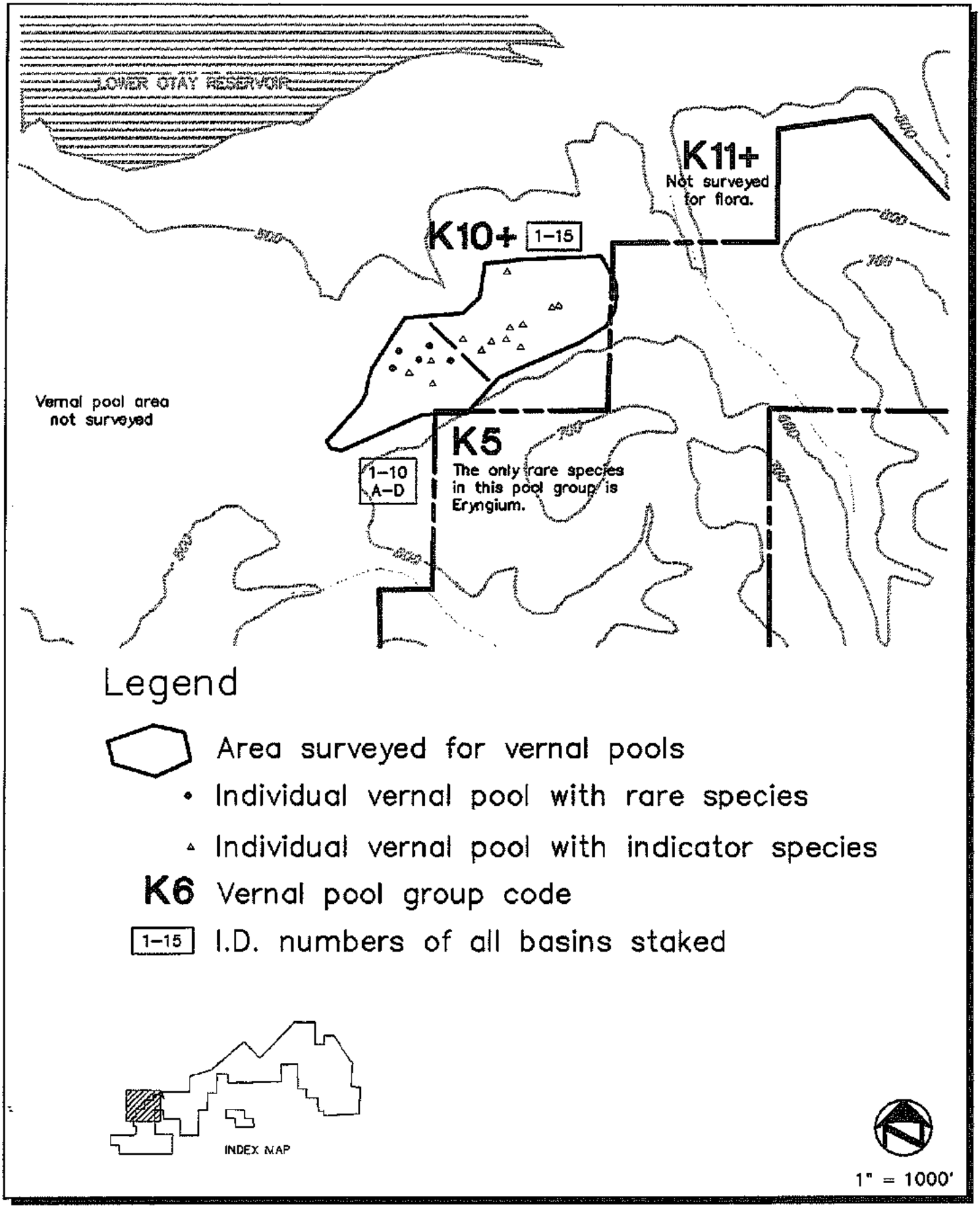
- Area surveyed for vernal pools
- △ Individual vernal pool with indicator species
- **K6** Vernal pool group code
- 1-15 I.D. numbers of all basins staked



1" = 1000'

Otay Ranch Vernal Pools
Lower Otay Lake - South Vernal Pool Group: K12+, K13+, K14+

FIGURE 11



Otay Ranch Vernal Pools

Lower Otay Lake - South Vernal Pool Group: K5, K10+, K11+

FIGURE 12

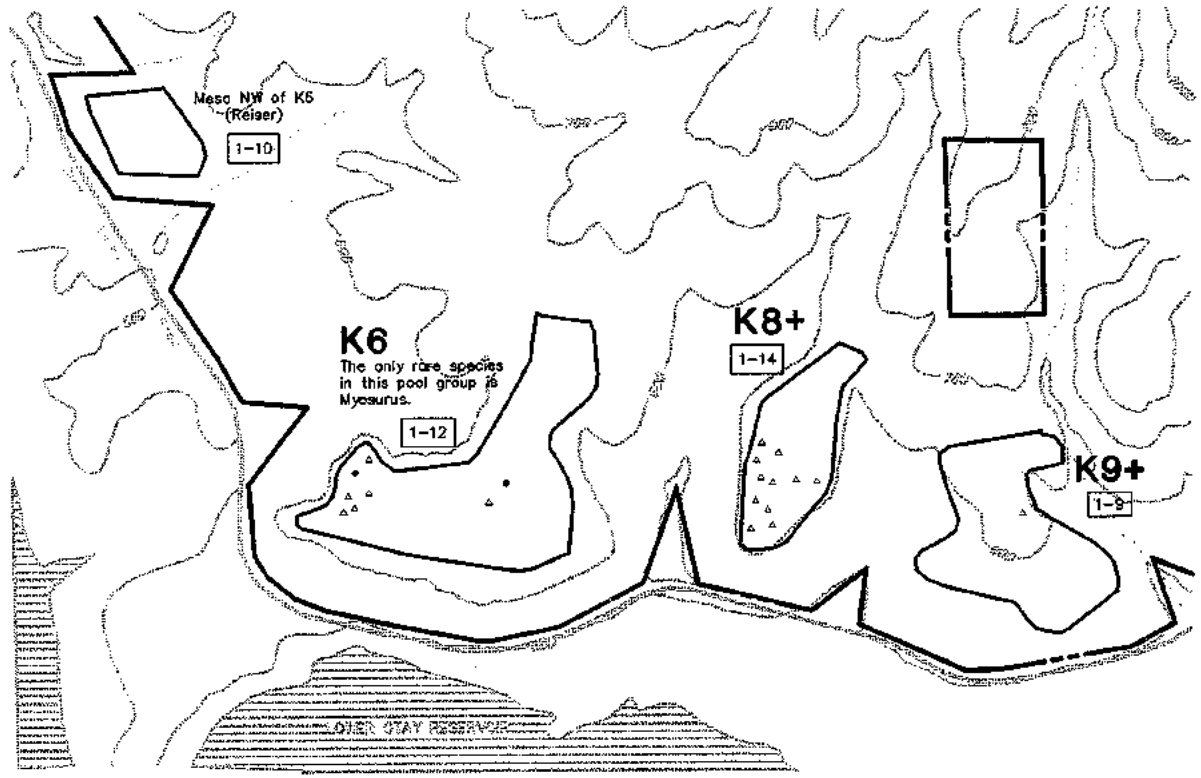
Little mousetail (*Myosurus minimus* var. *apus*), a rare vernal pool species known from only a few localities in the U.S. (Ellen T. Bauder, pers. comm.), was found in one pool on the K 6 mesa in 1990 and in two pools in 1990. Only two individuals of little mousetail were observ ed in 1990, and this was the only sighting of the species on Otay Ranch in 1990. In 1991, *Myosurus* numbered in the hundreds both the western and eastern pools. *Myosurus* was recorded from the R 1 Proctor Valley pools and the J 29 Otay Mesa/Space Station pools in previous years but has not been relocated at R 1 since 1986 or at J 29 since 1979.

Three vernal pools were identified on the K 6 mesa in 1990. In 1991, 5 additional pools were found for a total of 8 pools (Figure 13). Eleven pools were found on the K 8+ mesa. The mesa northwest of K 6 did not have any vernal pool indicator species. The only vernal pool species on the K 9+ mesa was *Psilocarphus tenellus*. Although Zedler (1987) considers it an indicator of vernal pool habitat, the present authors do not regard *Psilocarphus tenellus* as an indicator because it seems to grow more frequently in depressions that do not have other characteristics of wetlands. However, one of the basins on K 9+ (disturbed by a road), is dominated solely by *Psilocarphus tenellus* and this species occurs in association with two other facultative and obligate wetland species including cf. adobe popcornflower and *Juncus bufonius* var. *halophilus*. This one basin, therefore, is considered to be a vernal pool.

Plants dominating the basins on these mesa tops include *Hemizonia fasciculata* and *Erodium botrys* with occasional introduced grasses, *Stipa pulchra* and a few vernal pool species. The K 6 and K 8+ mesas each had six vernal pool species, five being common to both (Table 4).

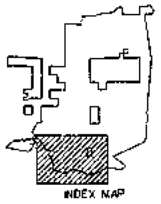
The only basin that met the criterion for hydrophytic vegetation was the one pool on K 9+ which was dominated by *Psilocarphus tenellus*. Four basins qualified as having wetland hydrology; all four were on the K 8+ mesa and had vernal pool indicator species.

The mesa that supports the K 6 vernal pool complex was the source of thousands of specimens of the quino checkerspot (*Euphydryas editha quino*) from the mid-1970s to the early-1980s. During this period, the K 6 mesa was visited each spring by the Stanford University biology group headed by Dr. Paul Ehrlich. Larvae of the butterfly feed on native *Plantago* species (Plantaginaceae) and adults utilize a variety of herbaceous annuals as nectar sources. The distribution of the quino checkerspot has declined dramatically over the past decade; it has not been observed on Otay Ranch since about 1982. This subspecies is recognized as a Category 2 candidate for listing as threatened or endangered by the USFWS, and the Service has received a petition for listing under the emergency provisions of the Endangered Species Act. The quino checkerspot is not restricted to vernal pools, but the mesa habitats that often support vernal pools also often support abundant populations of two plantain species: *Plantago bigelovii* within vernal pools and *Plantago erecta* on adjacent uplands in coastal sage scrub, chaparral and grassland. So, rather than being a vernal pool obligate species, the occurrence of the quino checkerspot at K6 was coincident with the occurrence of vernal pools there.



Legend

- Area surveyed for vernal pools
- • Individual vernal pool with rare species
- ◦ Individual vernal pool with indicator species
- **K6** Vernal pool group code
- 1-15 I.D. numbers of all basins staked



1" = 1000'

Otay Ranch Vernal Pools
Lower Otay Lake - North Vernal Pool Group: K6, K8+, K9+

FIGURE
13

During survey work in summer 1991, a variety of insects was observed on the K 6 area, including painted lady butterfly (*Vanessa cardui*), checkered white butterfly (*Pontia protodice*), Behr's metalmark butterfly (*Apodemia mormo virgulti*), spider wasps (*Pompilidae*), flower flies (Syrphidae), and bee flies (Bombyliidae). Also, an individual of the federal Category 2 candidate San Diego horned lizard was seen.

Proctor Valley

Proctor Valley is located upstream of Upper Otay Lake and southwest of Jamul. It is bounded by the Jamul Mountains on the southeast and San Miguel Mountain on the northwest. Vernal pools in this valley occur on old, highly weathered benches and in the valley bottom mostly on Olivenhain soils, but also on some Friant soils in the northern part of the valley. These vernal pool series include R 1, R 2+, R 3+, and R 4+ (Figure 4).

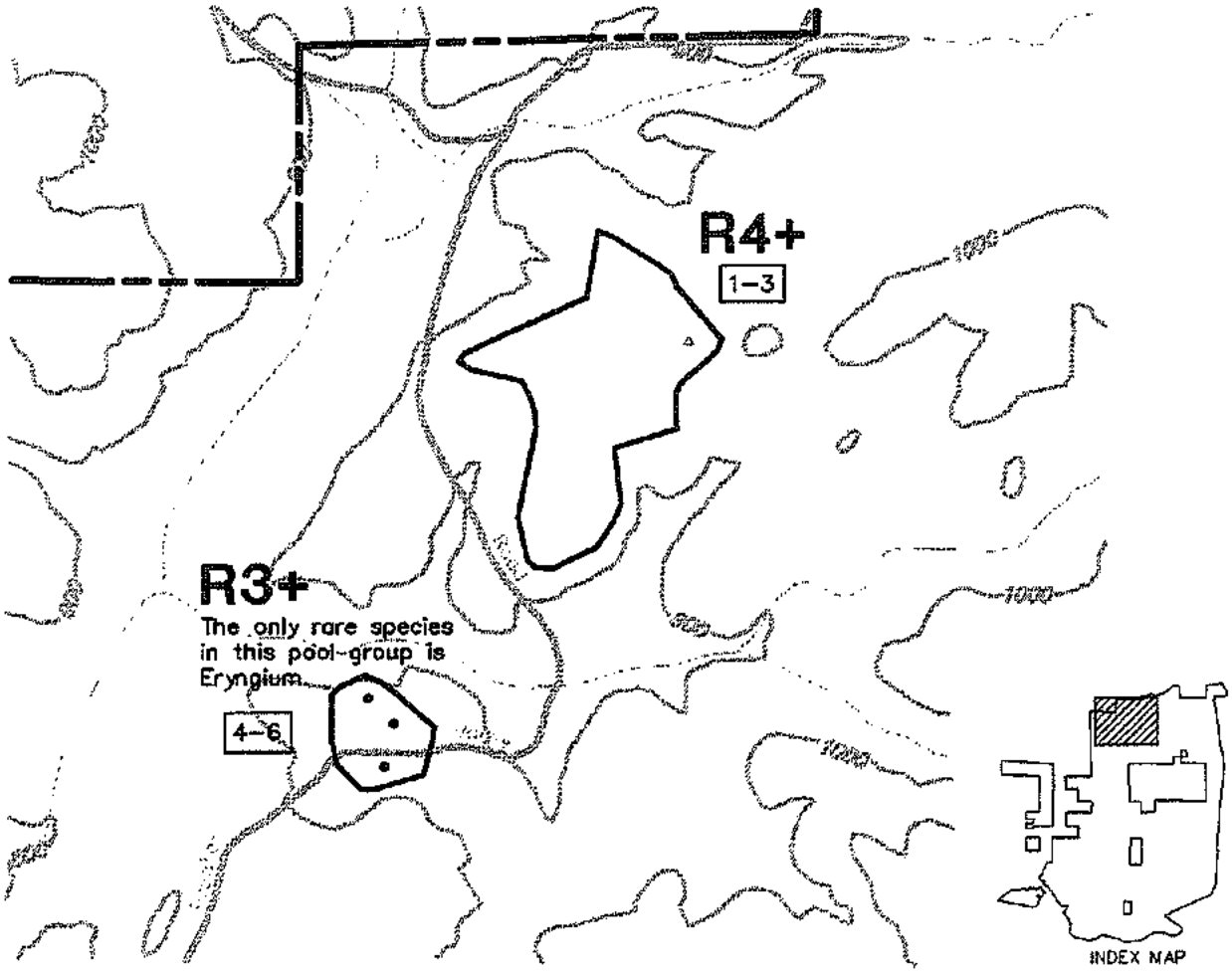
The dominant vegetation in the vicinity of these vernal pool groups is coastal sage scrub and valley needlegrass grassland; however, a locally unique chaparral association composed primarily of Munz's sage (*Salvia munzii*), *Eriogonum fasciculatum*, and *Viguiera laciniata* borders these pool groups.

The R 1 pool group is mostly on property owned by the City of San Diego and includes 14 basins with vernal pool indicator species, all of which have been impacted by vehicles driving through them (Figure 14). The R 2+ pool group is on a bench on the opposite (west) side of Proctor Valley Creek from R 1 on Baldwin property and includes nine undisturbed basins with vernal pool indicator species. In the upper Proctor Valley, R 3+ has three basins with vernal pool indicator species and R 4+ has one basin with an indicator species (Figure 15).

Eryngium aristulatum was present in all three vernal pools in the R 3+ area in both 1990 and 1991. One of the pools was disturbed by trash dumping and vehicular activity immediately adjacent to Proctor Valley Road. This pool may easily be restored by removing trash and smoothing ruts. Prevention of further damage will be a necessary challenge of resource management.

Myosurus minimus var. *apus* and *Navarretia fossalis* were recorded for the lower Proctor Valley R 1 group, but the *Navarretia* identification was considered uncertain (CDFG 1986). Neither of these rare plants was observed in Proctor Valley during the 1990 or 1991 floral surveys.

Vernal pool species present in the lower Proctor Valley pools included *Psilocarphus brevissimus*, *Callitriche longipedunculata*, *Crassula aquatica*, and *Deschampsia danthonioides*. The wetland species *Juncus bufonius*, *Lythrum hyssopifolia* and *Cotula coronopifolia* also were present. The R 2+ pool group has a unique assemblage of vernal pool fringe species including some large



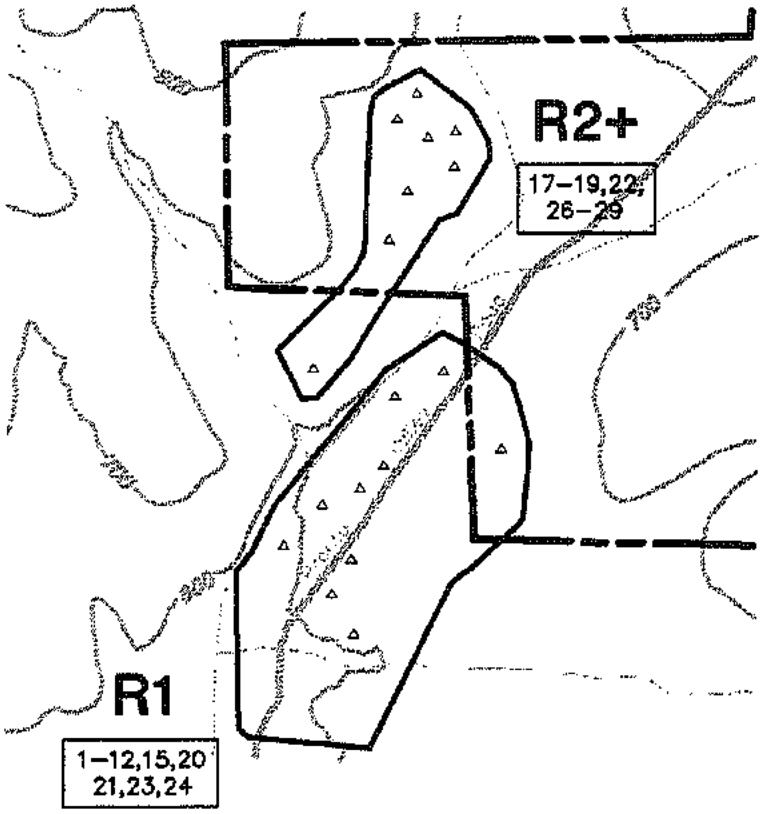
Legend

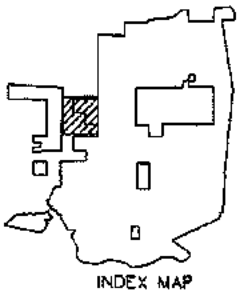
- Area surveyed for vernal pools
- • Individual vernal pool with rare species
- ▵ Individual vernal pool with indicator species
- **K6** Vernal pool group code
- [1-15] I.D. numbers of all basins staked

1" = 1000'

Otay Ranch Vernal Pools
Upper Proctor Valley Vernal Pool Group: R3+, R4+

FIGURE
14





Legend

- Area surveyed for vernal pools
- Individual vernal pool with indicator species
- **K6** Vernal pool group code
- [1–15] I.D. numbers of all basins staked

1" = 1000'

Otay Ranch Vernal Pools
Lower Proctor Valley Vernal Pool Group: R1, R2+

FIGURE 15

shallow basins dominated by *Allium praecox* and *Plantago erecta*, the primary host plant of the federal Category 2 candidate Quino checkerspot butterfly (*Euphydryas editha quino*). This area also has unusually stable, undisturbed soil surfaces, and is one of the only vernal pool areas on Otay Ranch that is not characterized by introduced grasses and weeds. Vernal pool species in the R 3+ group of upper Proctor Valley include *Callitriche*, *Deschampsia*, *Psilocarphus brevissimus*, *Eryngium*, and *Lythrum hyssopifolia*. The only vernal pool species detected in the R 4+ area was *Crassula aquatica*, found early in the growing season.

VERNAL POOL SURFACE AREA

Climatic variability, particularly rainfall, from year to year and through geologic time, causes a corresponding expansion and contraction of the area occupied by the biota unique to vernal pools. Vernal pool habitat area can be identified and quantified in any one year but it represents a short window of time within the broader context of long-term fluctuations in species populations and habitat area. The degree to which the area of vernal pools measured in one year matches the maximum area that has functioned as vernal pool habitat in recent history can be estimated subjectively by comparing yearly rainfall patterns. The amount of precipitation in the study year should be compared with the highest rainfall years rather than only considering average annual rainfall. Total rainfall in 1990 (7.29 inches) was only slightly lower than the average annual rainfall (10.86 inches) that occurred just within the last ten years (Table 5). This suggests that some additional basins not identified as vernal pools in 1990-1991 would have saturated conditions and would support vernal pool biota during higher rainfall years. We also suggest that individual basins identified as vernal pools would have a larger area occupied by vernal pool biota in higher rainfall years, and especially following more than one year of higher rainfall. The total surface area of vernal pools on Otay Ranch is expected to increase in some years and contract in other years. However, the groupings of vernal pools identified in this study are not expected to expand or contract dramatically. The changes in surface area would occur primarily in basins between the identified vernal pools and within identified pools. In most cases, the areas just outside a grouping of vernal pools either lacked distinct basin and mound topography or consisted of mounded topography that was tilted; these areas would not be expected to normally support vernal pool biota even in high rainfall years.

The seasonal pattern or distribution of precipitation also affects the development and extent of vernal pool habitat and may be more important than total rainfall. Whether the rain comes over a brief period or is distributed throughout the growing season will affect time of germination and water availability for seedling growth. Precipitation in 1990, although below the annual average, came in fairly evenly spaced storms through the growing season that allowed growth and survival of the short water duration vernal pool plant species in a large number of basins (i.e. *Psilocarphus brevissimus*). This pattern of rainfall did not allow ponding or saturation of soils

TABLE 5

ANNUAL PRECIPITATION IN THE YEARS 1980 TO 1990 AT LINDBERGH FIELD, SAN DIEGO, CALIFORNIA

YEAR	PRECIPITATION (inches)
1951-1980	9.32 average
1980	14.96
1981	10.24
1982	12.96
1983	18.78
1984	8.71
1985	8.66
1986	12.18
1987	11.60
1988	10.26
1989	3.83
1990	7.29
Average	10.86

to persist more than a few days at a time except on road pools. By contrast, precipitation in 1991 was average, but came in a few concentrated storms. This pattern of rainfall allowed for longer duration of ponding and soil saturation conditions and natural basins filled and retained surface water for at least several days.

As a result of 1990 field work only, the surface area of vernal pools was totaled for each pool group using the field measurements of individual pools (Table 6). The Otay Mesa pool groups have by far the greatest vernal pool area with a total of 4.77 acres. Proctor Valley has the next largest collective surface area of vernal pools with 0.30 acre, followed by Otay Valley with 0.27 acre, Lower Otay Lake South with 0.16 acre, Lower Otay Lake North with 0.14 acre, and Poggi Canyon with 0.02 acre. Looking at the pool groups separately, J 23-24 on Otay Mesa has the greatest vernal pool surface area followed by J 29-30, J 25, R 1 in Proctor Valley (owned by the City of San Diego), K 8+ of the Lower Otay Lake North area, K 1 of Otay Valley, R 2+ of Proctor Valley, J 31 South+ of Otay Mesa, K 5 and K 10+ in the Lower Otay Lake South area (both owned by the City), and R 3+ in upper Proctor Valley. All other pool groups had less than 0.05 acre of vernal pool surface area.

The total vernal pool surface area reflected fairly well the number of pools found in each area, though there was some variability in sizes of pools among mesas. The average size of vernal pools ranged from around 100 and 200 ft^2 on the J 25 and J 23-24 mesas to around 500, 600, and 700 ft^2 in the J 29-30, K 1, and R 3+ areas (Table 7). The greatest variability in pool sizes was in the J 29-30 and K 1 areas, probably because they had some of the largest pools in addition to having pools of smaller sizes.

The ratio of vernal pool/mound habitat to vernal pool surface area was determined for the largest pool groups (Table 7). Vernal pool/mound habitat is an area of land including and surrounding identified vernal pools including mounds, basins, and contributing drainage (watershed) area. Vernal pool/mound habitat was delimited by drawing the perimeter of an aggregate or cluster of vernal pools. If a pool was separated from a cluster by more than approximately 200 feet, the habitat in between was not included as vernal pool/mound habitat. This measurement is not intended to reflect the total theoretical watershed of vernal pools; this may include a larger area than the pool/mound habitat. J 29-30 area on Otay Mesa had the highest density of vernal pools with a ratio of vernal pool/mound habitat to vernal pool surface area of 33 as compared with 43 and 44 for J 23-24 and J 25 respectively. The K 1 and K 8+ mesas in the Otay Valley and Lower Otay Lake areas were intermediate in their densities of pools with ratios of 41 and 40 respectively. The Proctor Valley pool groups had the lowest densities of vernal pools reflected by their high ratios of pool/mound habitat to vernal pool surface area (50 for R 1 and 46 for R 2+).

TABLE 6
SUMMARY OF VERNAL POOL NUMBERS AND SURFACE AREA ON OTAY RANCH

Pool Group	# of Vernal Pools Recorded in 1986[a]	# of Vernal Pools Recorded in 1990	Surface Area: Total Vernal Pool-ft² (acres)		Surface Area: Average Vernal Pool-ft² SD[b]	
OTAY MESA						
J 29-30	12	170	81,771	(1.88)	481	(1,408)
J 31 South +	---	6	3,029	(0.07)	505	(587)
J 31 North +	---	2	289	(0.01)	145	(116)
J 23-24	51	531	104,995	(2.41)	197	(213)
J 25	12	151	16,656	(0.38)	110	(164)
OTAY VALLEY						
J 32 +	---	3	1,029	(0.02)	343	(184)
K 1	---	7	4,377	(0.10)	625	(1,039)
K 15 +	---	4	711	(0.02)	178	(147)
K 16 +	---	1	187	(0.0004)	187	
K 2	0	0	0		0	
K 17 +	---	2	919	(0.02)	459	(516)
POGGI CANYON						
M 2	2	5	727	(0.02)	145	(165)
M 5 +	---	1	157	(0.004)	157	
LOWER OTAY LAKE SOUTH	22	7	2,546	(0.06)	364	(230)
K 5[c]	---	9	1,954	(0.05)	217	(218)
K 10 +	---	4	726	(0.02)	181	(28)
K 12 +	---	2	1,206	(0.03)	603	(553)
K 13 +	---	1	346	(0.01)	346	
K 14 +						
LOWER OTAY LAKE NORTH	2	3	412	(0.01)	412	(137)
K 6	---	11	5,581	(0.13)	465	(448)
K 8 +	---	1	31	(0.001)	31	
K 9 +						
PROCTOR VALLEY	5	14	7,874	(0.18)	562	(489)
R 1	---	9	3,075	(0.07)	342	(301)
R 2 +	---	3	2,050	(0.05)	683	(427)
R 3 +	---	1	44	(0.001)	44	
R 4 +						

[a] Numbers are not comparable between years because surveys prior to 1990 were not exhaustive.

[b] Standard deviation is a measure of variability around the average.

[c] Only the east lobe of K 5 was surveyed in 1990.

TABLE 7

RATIO OF VERNAL POOL/MOUND HABITAT TO VERNAL POOL SURFACE AREA

Pool Group[a]	Vernal Pool Surface Area	Vernal Pool/Mound Habitat Area	Ratio of Vernal Pool/Mound Habitat to Vernal Pool Surface Area
OTAY MESA			
J 29-30	1.88	61.56	33
J 23-24	2.41	102.84	43
J 25	0.38	16.72	44
OTAY VALLEY			
K 1	0.10	4.13	41
LOWER OTAY LAKE			
K 8+	0.13	5.10	40
PROCTOR VALLEY			
R 1	0.18	9.04	50
R 2+	0.07	3.25	46

[a] Pool groups with less than seven vernal pools are not listed because mound area becomes too small to provide meaningful data. K 5 and K 10+ are excluded because vernal pools continue outside area surveyed.

RESTORATION

Introduction

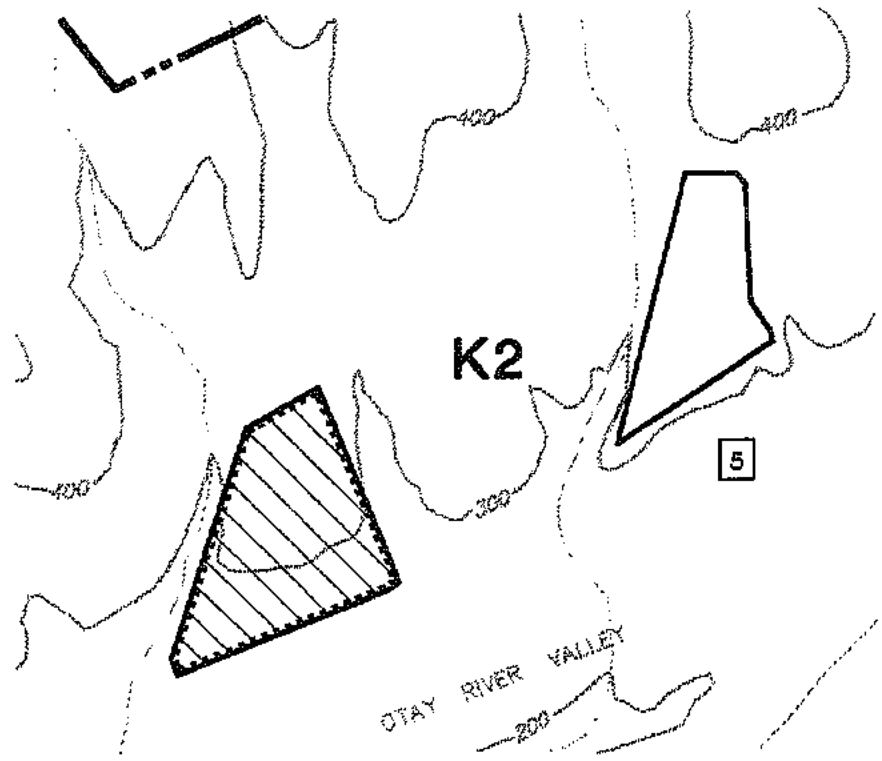
Any restoration should be done in accordance with a comprehensive plan that identifies specific needs and potential benefits, detailed restoration plans akin to landscape construction plans, and provisions for monitoring, maintenance and reporting. Areas available for restoration within the Resource Management Plan are shown in Figures 16-20. Detailed surveys of each potential restoration site are essential prior to initiating detailed planning. All work should be done by skilled individuals under the direction of a qualified biologist. It is anticipated that the amount of restoration required would be part of an overall mitigation program carried out under the Resource Management Plan for Otay Ranch. It is recommended that restoration efforts be directed initially toward the areas that have high potential resource value and require measures that are less intrusive, less costly and more likely to succeed, rather than areas of the ranch that are heavily disturbed, lack unique biological characteristics, and would require extremely expensive, highly experimental restoration techniques with lower chances for success.

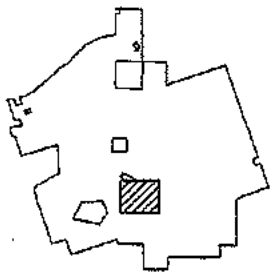
Restorable Area

There are areas with unique bio. charac. (Navarretia's historical location of Myosurus & Orc) that are heavily disturbed.

Note that the benefit is also less

The amount of area potentially restorable to vernal pool habitat was estimated by identifying sites that are disturbed but that have mounded topography or other features suggesting necessary hydrology or soils. The known historical distribution of vernal pools also was considered an important indicator of restoration potential. Potentially restorable sites were delimited on maps (not included in this report) and their areas calculated with a planimeter (Table 8). The areas are approximate, and site specific field evaluations of restoration potential would reveal more accurate and specific information. Within each restorable mound habitat area, a smaller amount of habitat (ie. basins) is restorable to vernal pools; this constitutes the vernal pool surface area that is restorable. Based on the assumptions that there is a limited amount of substrate suitable for restoration or creation of vernal pools in a Mima mound field and that the ratio of mound/pool habitat to extant vernal pool surface area reflects the ratio of disturbed mound habitat to area of substrate suitable for restoration, we calculated a range of areas of vernal pool surface area that are potentially restorable (Table 8). The minimum surface area restorable would be some number greater than zero, or zero in cases where the chances of success of restoration largely are unknown. The maximum surface area restorable for each pool group was calculated by dividing the ratio of pool/mound habitat area to pool surface area by the area of restorable habitat. The lowest ratio on Otay Mesa (33 from J 29-30) was used to obtain the maximum surface area restorable for the Otay Mesa pool groups, whereas the lowest ratio on the rest of Otay Ranch (40 from K 8+) was used for all other pool groups. It should be noted that such estimates are theoretical. They are not absolute nor are they a measure or guideline for determining success.





INDEX MAP

Legend

Area surveyed for vernal pools

K6 Vernal pool group code

18–21 I.D. numbers of all basins staked

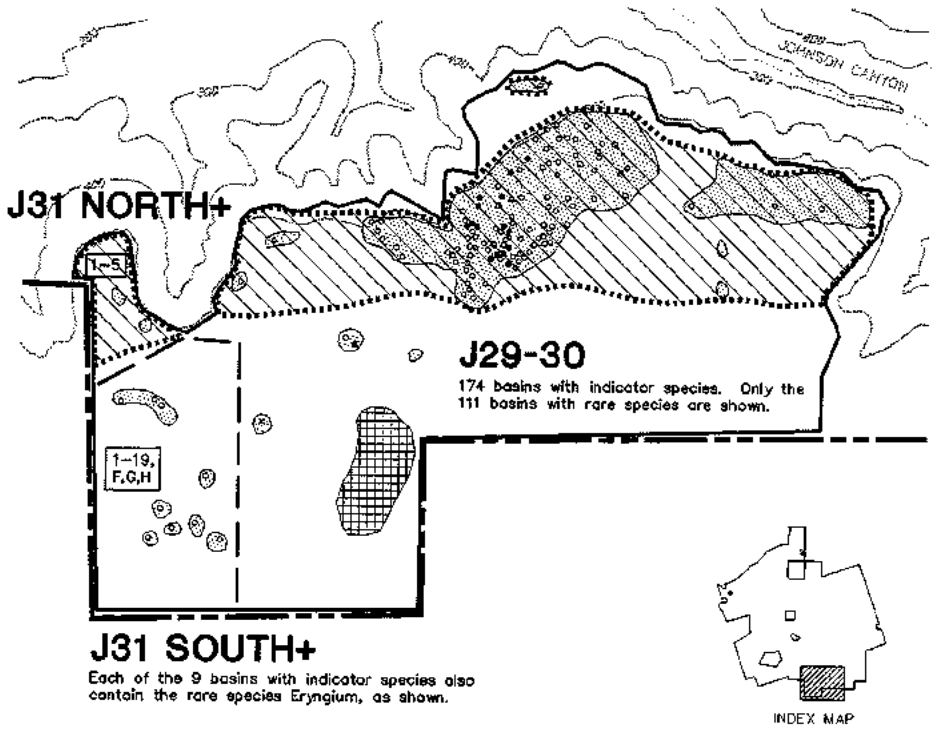
Area Available for Restoration

1" = 1000'

Otay Ranch Vernal Pools

Vernal Pool Group K2 Available Restoration Area

FIGURE 16



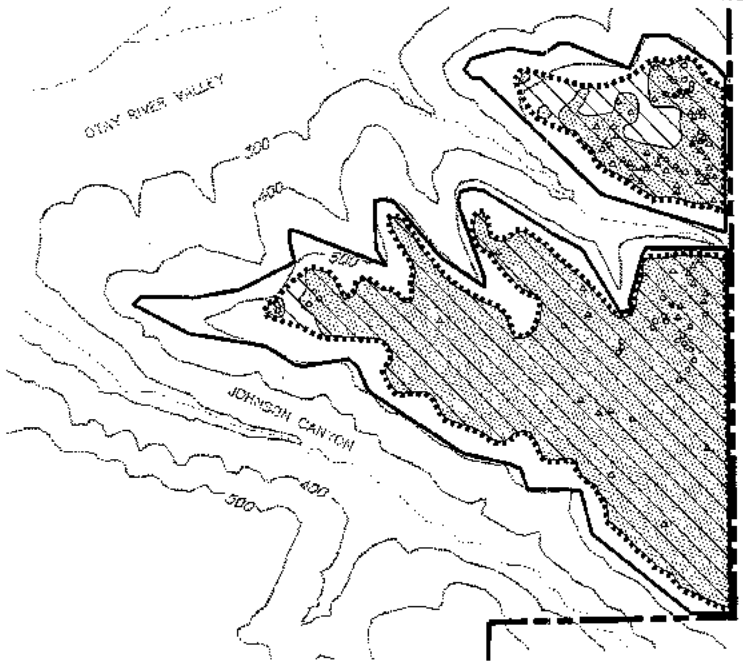
Legend

- Area surveyed for vernal pools
- Area of vernal pool habitat with indicator species
- *Lepidium latipes*
- ◦ Individual vernal pool with *Eryngium aristulatum*
- △ Individual vernal pool with *Pogogyne nudiuscula*
- × Individual vernal pool with *Navarretia fossalis*
- • Individual vernal pool with both *Eryngium* and *Pogogyne*
- ▲ Individual vernal pool with both *Eryngium* and *Navarretia*
- **K6** Vernal pool group code
- 18–21 I.D. numbers of all basins staked
- Area Available for Restoration

1" = 1000'

Otay Ranch Vernal Pools
Vernal Pool Groups J29-30 & J31 North+ Available Restoration Areas

FIGURE 17

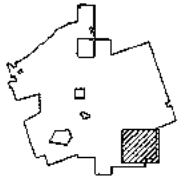


J25

151 basins with indicator species. Only the 59 basins with rare species are shown.

J23-24

533 basins with indicator species. Only the 45 basins with rare species are shown.



INDEX MAP

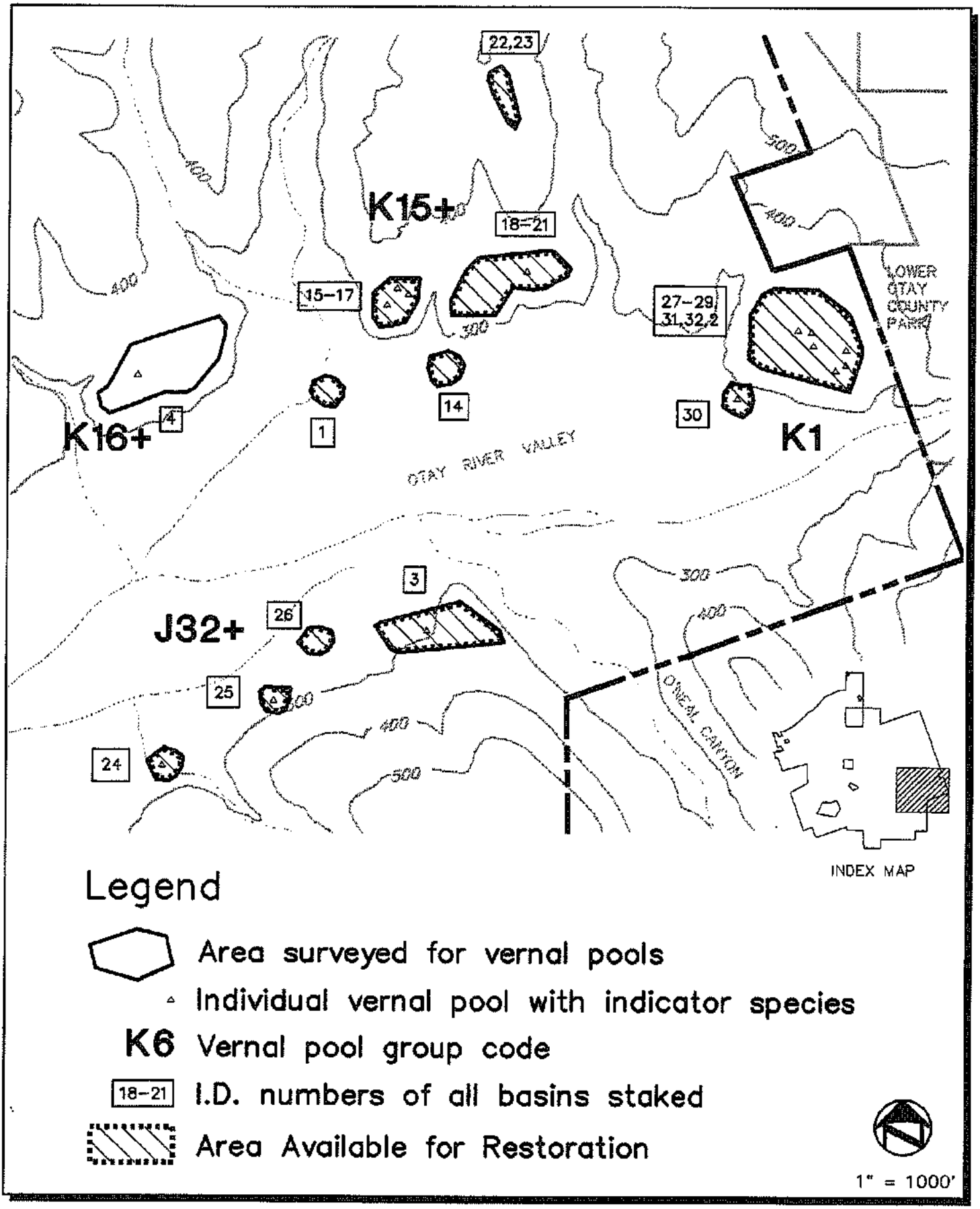
Legend

- Area surveyed for vernal pools
- Area of vernal pool habitat with indicator species
  - ◦ Individual vernal pool with *Eryngium aristulatum*
  - △ Individual vernal pool with *Pogogyne nudiuscula*
  - • Individual vernal pool with both *Eryngium* and *Pogogyne*
- **K6** Vernal pool group code
- 18–21 I.D. numbers of all basins staked
- Area Available for Restoration

1" = 1000'

Otay Ranch Vernal Pools
Vernal Pool Groups J23-24 & J25 Available Restoration Areas

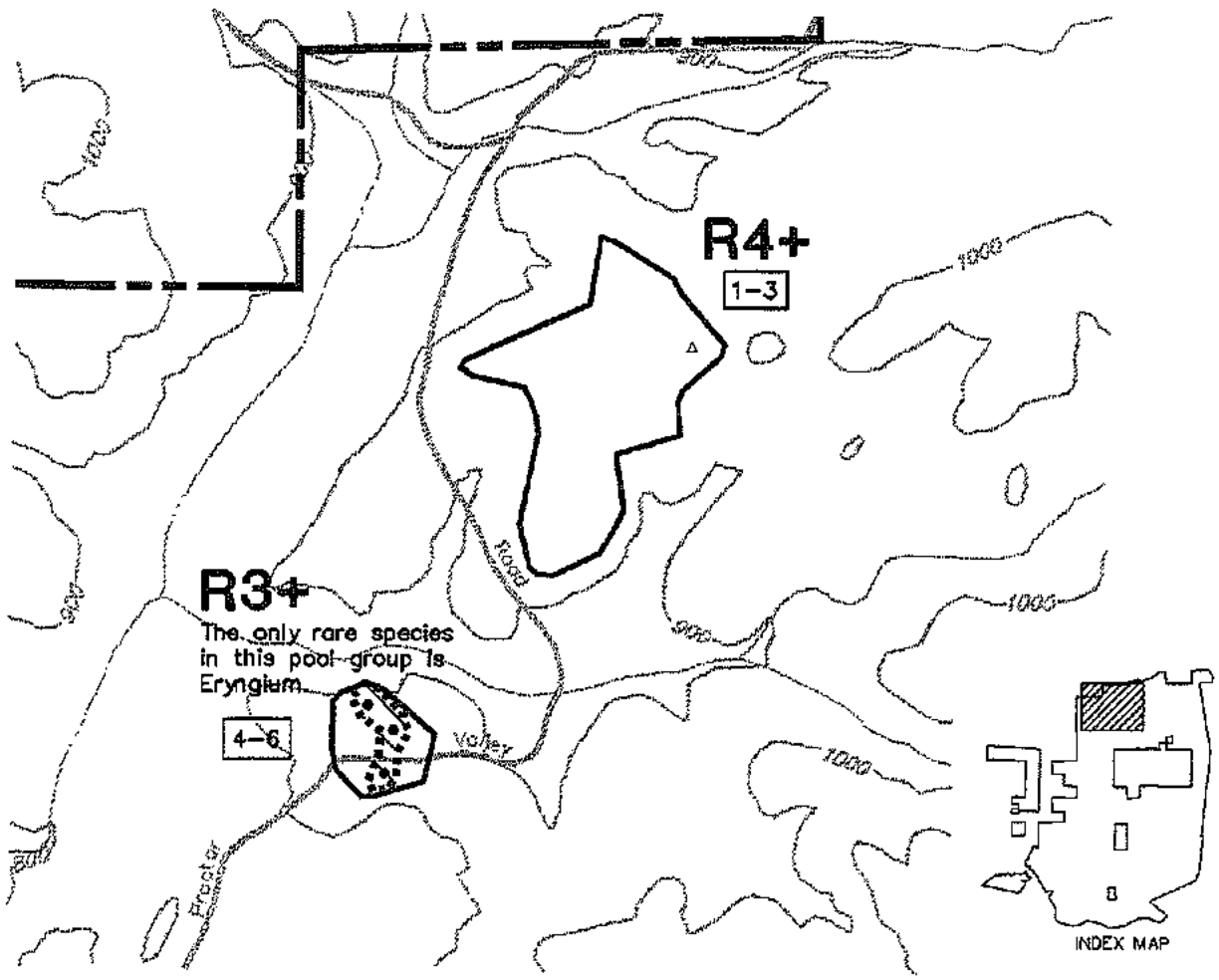
FIGURE
18



Otay Ranch Vernal Pools

Vernal Pool Groups J32+, K1 & K15+ Available Restoration Areas

FIGURE
19



Legend

- Area surveyed for vernal pools
- • Individual vernal pool with rare species
- △ Individual vernal pool with indicator species
- **K6** Vernal pool group code
- 1-15 I.D. numbers of all basins staked
- Area Available for Restoration

1" = 1000'

Otay Ranch Vernal Pools
Vernal Pool Group R3+ Available Restoration Area

FIGURE 20

TABLE 8
POTENTIALLY RESTORABLE VERNAL POOL HABITAT

Pool Group	Disturbance	Restoration Class[a]	Restorable Mound Habitat Area ft² (acres)		Range of Restorable Vernal Pool Surface Area[b] Minimum ft²	Maximum ft² (acres)	
OTAY MESA							
J 29-30	lightly graded	3	3,833,368	(88.00)	> 0	116,163	(2.67)
J 29-30	heavily graded	4	4,193,956	(96.28)	0	127,090	(2.92)
J 31 south+	heavily graded	4	2,817,025	(64.67)	0	85,364	(1.96)
J 23-24	scraped	2	27,417	(0.63)	> 0	830	(0.02)
J 23-24	road	2				existing pools	
J 25	scraped	2	85,597	(1.96)	> 0	2,593	(0.06)
J 25	road	2				existing pools	
OTAY VALLEY							
K 15+	vehicles	1 or 2				existing pools	
K 16+	disced	2	326,042	(5.19)	0	5,651	(0.13)
K 2 west	disced	2	310,001	(7.12)	0	7,750	(0.18)
K 2 east	disced	2	191,167	(4.39)	0	4,779	(0.11)
K 17+	disced	2	286,751	(6.58)	0	7,169	(0.16)
POGGI CANYON							
M 2	disced	2	465,001	(10.67)	0	11,625	(0.27)
M 5+	disced	2	364,251	(8.36)	0	9,106	(0.21)
LOWER OTAY LAKE							
K 6	grazed	1 or 2	1,674,003	(38.43)	0	41,850	(0.96)
PROCTOR VALLEY							
R 1	vehicles	1 or 2				existing pools	
R 3+	vehicles & grazed	1				existing pools	

a See Exhibit 5

b Extrapolated assuming the ratio of vernal pool mound habitat area to vernal pool surface area could be as low as 33 for Otay Mesa, and 40 for other areas (see Table 7).

Areas on the Otay Ranch with some potential for restoration of vernal pool habitat have been classified by the type of disturbance present and generalized restoration measures that could be taken (Figure 21 and Table 8).

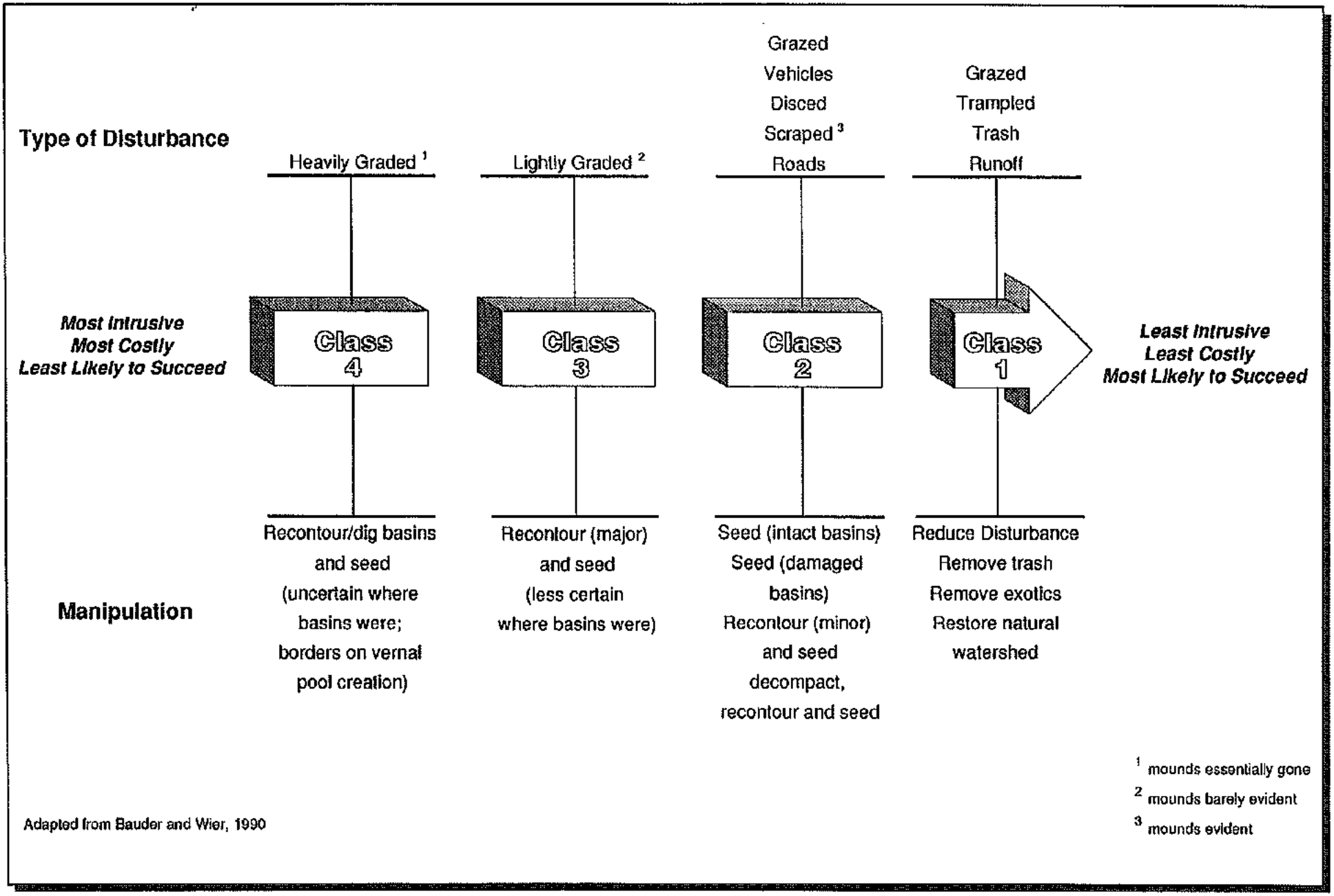
The restoration measures that are least intrusive, least costly, and most likely to succeed are classified as habitat enhancement by Bauder and Wier (1990) (Class 1 in Figure 21). They would include prevention of disturbance such as removing livestock grazing, excluding vehicles, and excluding dumping. This could be effected by fencing and/or signing an area and providing site security. More extensive enhancement measures could be effected by removing trash, weeding exotic species, and altering hydrology to restore natural watershed conditions (See subsequent section on Restoration Techniques and Methods). All vernal pool groups could benefit from some of these measures. Because we identified cattle trampling as a disturbance in many vernal pools (several with sensitive species) and the grazing effect of cattle also may cause adverse impacts to flora, the removal of cattle in the Otay Mesa pool groups (J 29-30, J 23-24, J 25) would be effective. Another enhancement measure applicable to all pool groups (except R 2+ in the Proctor Valley area) is the removal of exotic plant species; in highly disturbed areas such as K 2, K 16+, K 17+, M 2, M 5+ and R 1, this could be coupled with reseeding of upland habitat with native grassland and coastal sage scrub species. The large vernal pool with *Eryngium* in R 3+ in upper Proctor Valley could be enhanced by removing the trash and erecting fencing along Proctor Valley Road.

Sources of Disturbance

Vernal pools that could be restored by seeding, minor recontouring of basins, or decompacting and recontouring include those that have been disturbed by heavy grazing, vehicles, discing, light scraping, and formation of dirt roads (Class 2 in Figure 21). These disturbances can result in depletion of the native flora, invasion of exotics and alteration of hydrology, all factors that mask the true or potential function of the vernal pool.

Grazing

Grazing may have depleted vernal pool plants in some areas. On K 6 north of Lower Otay Lake, however, there is evidence to the contrary, because approximately the same number or greater of vernal pools were found after the addition of sheep as before (Beauchamp and Cass 1979, Bauder 1986, and both years of this study). Nevertheless, manipulations could recover additional vernal pool habitat if the basins were capable of supporting vernal pool plants in the past. We would recommend excluding livestock, hand weeding exotics from basins, and seeding with native vernal pool species using seed obtained from the same mesa.



Otay Ranch Vernal Pools

Manipulation of Vernal Pool Habitat

FIGURE 21

Discing and Scraping

Discing and scraping in several areas on Otay Ranch have filled vernal pool basins so that they no longer appear to function as vernal pools. The basin and mound topography in disced and scraped areas is still evident suggesting that restoration of these physical features followed by reseeding may be effective. This type of restoration is being attempted elsewhere in San Diego County and the results of these efforts are preliminary but encouraging. Disturbed areas with these characteristics are found within nearly all of the vernal pool groups, but are particularly evident in the following locations:

Otay Valley Vernal Pool Group: the entire area of K 16+, K 2, and K 17+;

Poggi Canyon Vernal Pool Group: the entire area of M 2 and M 5+;

Otay Mesa Vernal Pool Group: local areas along the southern edge of J 29-30 including some road pools; road pools and a southeast to northwest scrape on J 23-24; and road pools, a scrape along the southern margin of the mesa, and a large circular scraped on J 25.

Restoration of vernal pool habitat potentially is achievable in all these areas by removing soil that previously was pushed into basins from adjacent mounds, and revegetating with seed collected from plants in the nearest adjacent area.

Dirt Roads and Other Grading

Vernal pools have been degraded or eliminated where dirt roads are established or where there is heavy vehicle damage; groups with substantial vernal pool area degraded by roads include J 23-24, J 25, J 29-30, K 15+, and R 1 (Table 9). Some of these vernal pools could be restored by closing the roads and decompacting, recontouring, and seeding basins.

Areas that have been graded to the degree that vernal pools were filled but mounds are still evident but not distinct may have some potential for restoration through major recontouring and seeding of basins (Class 3 in Figure 21). Restoration in these areas would be costly and difficult. Sometime prior to acquisition by The Baldwin Company, the southern middle part of J 29-30 was graded lightly and farmed. Since 1978 (Beauchamp and Cass, 1978), this area has supported only a few scattered vernal pools (Bauder 1986; Cass, pers. comm.). This area is approximately 88 acres.

Also on J 29-30 some areas have been graded heavily and farmed (92 acres in J 29-30 and 65 acres in Space Station-J 31 South+). The vernal pools were filled and the mounds now essentially are gone (corresponds to Class 4 in Figure 21). This heavily disturbed habitat still supports 9 shallow vernal pools within the Space Station lease area that had *Eryngium*, and 4

vernal pools in the southwestern part of J 29-30, two of which had *Navarretia fossalis* and *Eryngium*. This habitat also had the rare species *Myosurus minimus* var. *apus* in 1979 (not relocated in 1990-91). Restoration (or creation) of vernal pools in this area would require major recontouring or digging of basins and would be less likely to succeed if locations of former basins cannot be determined. Although the measures to restore vernal pools would be the most intrusive, most costly, and least likely to succeed, this area potentially would have great value because of the possibilities for reintroducing the very rare vernal pool species *Myosurus* and increasing the distribution of *Navarretia*. *Myosurus* was found only on K6 during the period 1989-1991, and there are no other specific historic records for Otay Ranch that would support its reintroduction elsewhere. *Navarretia fossalis* was historically present in the K2 pools as well as Space Station and J31 South+. The lack of specific ecological information on this species suggests that the best chances for its populations are in known historic sites. However, if additional ecological information indicates other sites are appropriate, then these should be considered as well. This information, and the success of *Navarretia* or *Myosurus* establishment elsewhere (i.e., within the northern J29-30 area or J23-24 or J25) could reduce the need for preservation and enhancement of southern J29-30, for example.

Restoration Techniques and Methods

Prior to commencement of a restoration project, the subject site should be surveyed thoroughly for floral and faunal resources, soils should be studied, and topography should be considered carefully. Also, once a specific restoration program, including methods for monitoring, has been developed, the proposal should be reviewed by appropriate biologists and resource managers. A biologist or resource manager also should supervise the project in the field. Timing of the work is critical to success. In general, earth movement and use of vehicles should be done when soils are dry. Seeds are best collected in late spring and through the summer (collection of some species requires a state collection permit). Seeding is most successful if completed before the first rains of the fall. The following general techniques may be used.

Decompaction

Decompaction of abandoned dirt roads and trails that traverse vernal pools and associated upland habitat should be accomplished with as little as possible additional damage to the pools and associated habitat. Decompaction loosens the soil, allows rain to penetrate, and accommodate normal plant growth. In vernal pools, because vehicles splash soil out of the pool, there may be less of a need for decompaction than either soil removal or return of the original pool soil. Heavy machinery should be used only where there is sufficient room to maneuver without damage to other pools and undisturbed uplands. If this cannot be accomplished, then work should be done with hand tools. Non-basin areas and slopes should be covered with biodegradable erosion control fabric.

Sculpting, Recontouring

The goal of sculpting and recontouring is restoration of the original topography and drainage patterns. In roads that have been decompacted, earth movement may be accomplished using machinery. If this cannot be done without additional damage to vernal pool and adjacent upland habitat, resculpting and recontouring should be done with hand tools. Berms alongside dirt roadways should be smoothed out where they interrupt drainages or have filled portions of pools. Between pools or basins, soil in berms can be used to reconstruct Mima mound topography. Within basins, ruts should be smoothed by hand.

Reseeding Pools

Seed never should be introduced to natural, undisturbed pools (of which there are few on Otay Ranch). A species (plant or animal) can be reintroduced into a pool where it has been extirpated by disturbance, but not where it has been extirpated due to natural processes. Therefore, prior to reintroduction, pools should be monitored for more than one year so that the absence of the species in question has been verified.

Reseeding should be done only with seeds gathered in immediately adjacent pools. Exceptions for Otay Ranch could be made for a few species where there are no known adjacent pools to use as a source: *Orcuttia* and *Myosurus* on J 29-30, *Myosurus* on R 1. If enhancement of *Navarretia* on J 29-30 was a goal, then it may be necessary to gather seed from offsite (J 13 for example) because the population on J 29-30 is so small that it probably would not yield many seeds. Some species are difficult to collect by hand, and therefore it may be necessary to collect seed by a combination of plucking, raking, and vacuuming (Zedler and Scheidlinger 1986). This technique would be most appropriate for reconstructed road pools that often are devoid of most of the vernal pool flora, including both rare and common vernal pool species. The primary disadvantage of the raking and vacuuming technique is that it is not selective, and many weed seeds also are gathered. This would be less of a problem if seeds were gathered after a year with greater than average precipitation, when most weeds are at a disadvantage. When water stands in basins for over a month, most weed species will die as they did in the Miramar pools (Bauder 1987). Seed collections should be conducted to not impact adversely the source pools by depleting the seed crop of any species and should conform to the current Fish and Wildlife restrictions on the collection of the federally listed endangered San Diego mesa-mint (*Pogogyne abramsii*). The San Diego mesa-mint example is applicable to the sensitive species on Otay Ranch even if the Otay Ranch species currently are not listed as endangered. Most are annuals with low population densities and are biologically although not legally endangered. These restrictions state that it "...is authorized to remove and reduce to possession a maximum of 5 percent or less of the seeds, plant parts, or whole plants annually available from any of the pools specified...." (Fish and Wildlife Service, Permit No. Zedlph-2, 1987). All seed sources and destinations should be clearly marked on maps that are made a part of published monitoring reports, circulated at a minimum to the U. S. Fish and Wildlife Service; Natural Heritage Division, California Department of Fish and Game; San Diego Natural History Museum.

Reseeding Non-Pool, Associated Habitat

Seeds should be collected by hand from adjacent areas and sown by hand. In some cases it may be necessary to prepare the seed bed by scarifying the surface of the soil and/or mulching with weed-free material.

Creation of Vernal Pools

Habitat creation should be employed only where there are no other options. Prior to any efforts to develop artificial habitat, the area should be surveyed carefully for the existence of natural pools, whether disturbed or not. Artificial habitat should not supplant restorable natural vernal pool habitat nor adversely affect the associated habitat. Seeding protocol should be the same as for restoration. Before the commencement of an artificial habitat project, the location, methods, performance standards, and monitoring procedures should be reviewed by biologists, resource managers, and the general public.

The least radical method of creating additional vernal pool habitat is to start with existing, intact depressions or swales that share similar substrate with nearby areas sustaining vernal pools. The assumption is that these depressions or swales would be fully developed vernal pools if the mesa top were more level, thus retaining water longer. A pilot project near Sacramento used check dams to impound water in existing swales (Sugnet and Associates 1989).

A more costly and risky procedure is to create habitat de novo. A variety of methods that has been used was presented at the Restoration and Creation of Vernal Pools Workshop, held in February, 1989 under the auspices of the California Department of Fish and Game in Sacramento, California.

Exotic Plant Removal

Exotic plant removal and control is one of the most difficult tasks to address, but also is one of the measures that greatly would promote native species populations and ecological health of vernal pools. Once exotics become established, there are few selective methods of removal available. If exotics have become established because of altered hydrology, they usually can be removed when the hydrological problems are resolved (e.g., *Typha* invasion). Hand weeding can be successful if performed at the correct time of year (Bauder 1989, Wood pers. comm.), but it is very time consuming and is used best for small areas. Weeding of annuals should be completed prior to seed set of the exotic plant to be removed and in a manner that disrupts native vernal pool and upland plants least.

Saturation of an area with seeds of native plants may help improve the competitive stance of natives versus exotics. Likewise, revegetating disturbed areas with natives should reduce the seed source of exotics.

The effects of fire are not well known, hence its use as a restoration tool in vernal pools is controversial. In some cases fire may enhance exotics (Zedler and Scheid 1988), but The Nature Conservancy has noticed positive effects at a number of preserves where controlled burns were used (Reiner 1990).

Priorities for Restoration

Restoration of vernal pool basins and adjacent upland habitat potentially has several benefits to conservation and management of the Otay Ranch vernal pools (Table 9), including: maximizing the area of vernal pool habitat; re-establishing sensitive species in areas where they have been extirpated and therefore stabilizing its population; expanding the distributions of sensitive vernal pool species and other vernal pool species in areas where they occur but have been reduced by disturbance or competition with weeds; and controlling exotic species in pools and on adjacent uplands. It is anticipated that restoration would be part of an overall mitigation program consistent with the Resource Management Plan (RMP). The amount of restoration required would reflect anticipated impacts. Essential steps of the vernal pool restoration and management plan would be: preparation of detailed restoration plans including establishment of individual project goals and timelines; coordination with appropriate resource regulatory agencies; completion of site restoration work; monitoring; maintenance; and remediation. Restoration plans for vernal pools should be prepared at a detail similar to high-quality riparian habitat restoration plans, and should be preceded by thorough site surveys, consideration of microtopography, distribution of soils, existing habitat values, and drainage patterns. Restoration design should be carried out only by trained biologists and should be subject to review by resource regulatory agencies and other vernal pool experts. Following successful completion of initial site restoration work, the project should be maintained and monitored pursuant to the stated project goals. Generally, it is anticipated that to document project success, monitoring of restoration programs would occur over three to five years.

Establishing success criteria for vernal pool restoration will be done on a case-by-case basis depending on the resources involved and the type of restoration proposed. For instance, the success of construction and maintenance of a fence to prevent livestock or vehicular access to a vernal pool area as a restoration/mitigation measure would be simple and inexpensive to evaluate. However, the success of a vernal pool creation project would be difficult to measure without first establishing objective, measurable success criteria.

The greatest opportunities for restoration occur in the Otay Mesa pool groups (J29-30, J31 South+, J23-24, and J25) where: the largest amount of restorable habitat exists; re-establishment of highly sensitive species is suggested as appropriate based on their former, documented distributions there; expansion of existing sensitive species populations would greatly improve the chances of survival of some species (particularly *Pogogyne nudiuscula*); and

TABLE 9. SUMMARY OF IMPORTANT VERNAL POOL RESTORATION BENEFITS

Vernal Pool Groups	Amount of Restorable Vernal Pool/ Mound Habitat[f] (Acres)	Restoration Class	Re-establish Sensitive Species[a,b]	Expand Existing Sensitive Species	Control Exotic Species
Otay Mesa					
J 29-30	184.3	1,2,3,4	N, O, M	P, E	High
J 31 South+	64.7	4	M, N, O	N	High
J 31 North+	0	1,2	---	---	Low
J 23-24	0.6	1,2,3	---	P, E	High
J 25	1.9+	1,2,3	---	P, E	High
Otay Valley					
J 32+	Low*	1	---	---	Low
K1	Low*	1,2	---	---	High
K15+	Low*	1,2	---	---	Low
K16+	5.2	3,4	---	---	Low
K2	11.5	3,4	N	---	Low
K17+	6.6	3,4	---	---	Low
Poggi Canyon					
M2	10.7	3,4	---	---	Low
M5+	8.4	3,4	---	---	Low
Lower Otay Lake South					
K5	Low*	1	---	E	Moderate
K10+	Low*	1	---	---	Moderate
K12+	Low*	1	---	---	Moderate
K13+	Low*	1,2,3	---	---	Moderate
K14+	Low*	1	---	---	Moderate

Table 9 (Continued)

Vernal Pool Groups	Amount of Restorable Vernal Pool/ Mound Habitat[1] (Acres)	Restoration Class	Re-establish Sensitive Species[a,b]	Expand Existing Sensitive Species	Control Exotic Species
Lower Otay Lake North					
K6	38.4	1,2	---	M	Moderate
K8	Low*	1,2	---	---	Moderate
Proctor Valley					
R1	High**	3,4	M, N(?)	---	High
R2+	Low*	1	---	---	Low
R3+	Low*	1,2	---	E	Moderate
R4+	Low*	1	---	---	Low

[a]. Species Abbreviations

P	=	*Pogogyne nudiuscula*
E	=	*Eryngium aristulatum* var. *parishii*
N	=	*Navarretia fossalis*
O	=	*Orcuttia californica*
M	=	*Myosurus minimus* var. *apus*

[b]. Based on known historical distributions and assumed habitat requirements.

* Not estimated; expected to be small amount of area.

** Not estimated; expected to be large amount of area.

[1] Vernal pool/mound habitat is an area of land surrounding and including identified vernal pools including mounds, basins and contributing drainage (watershed) area.

controlling the exotic vernal pool dominant *Lolium perenne* would cause native species to dominate a large number of vernal pool basins. Also, the Otay Mesa vernal pool groups offer a wide range of vernal pool restoration opportunities (Figure 21) including large areas that would require less intensive manipulation. Among the potential restoration benefits, rescuing the population of *Pogogyne* through site preservation and restoration is considered extremely important. Also important is establishing a large population of *Navarretia fossalis*. Presently, there is a small population in an area dominated by *Lolium*. Establishment of *Navarretia* within the less disturbed habitat to the north would improve its chances of survival.

It should be noted that the vernal pool resources in the southern parts of J29-30 including J31 South + are degraded in comparison to most of J23-24 and J25, and as a consequence, restoration of J29-30 and J31 South + would require intensive, expensive measures relative to J23-24 and J25. Also, examination of Table 9 reveals a huge acreage of potentially restorable vernal pool habitat on J29-30 (184.3 acres) in comparison to the other large mesas. J29-30 is indeed a large mesa, much or all of which probably contained vernal pools prior to agricultural use (based upon field work and examination of current aerial photographs). The restorable area (184.3 acres) includes land that is disturbed to varying degrees. It is generally more disturbed toward the south where the land has been leveled, mounds are no longer apparent, and there are only a few occurrences of vernal pool indicator species. It is less disturbed toward the north where the land has been cultivated but not successfully leveled, mounds sometimes are apparent, and occurrences of vernal pool indicator species are few. Therefore, when one evaluates the restoration potential of J29-30, it is critical to keep in mind the large extent of highly disturbed land and the extensive, intensive restoration that would be required over much of the area. Much of this area would be a very low priority with respect to restoration because of the high degree of disturbance. It is anticipated that most necessary mitigation under the RMP would be carried out on J23, 24, 25 and the undisturbed sections of J29,30. Because of cost considerations, restoration and management should be directed to more promising areas of research, restoration and protection.

Generally, restoration within other vernal pool groups potentially provides significantly less area, fewer pools, and fewer sensitive species (*Pogogyne* has not been recorded north of the Otay River and is inappropriate for introduction based on our current knowledge). The Otay Valley and Poggi Canyon pools mostly are heavily disturbed and would require extensive restoration that should be considered experimental (i.e., K17+, K2, K16+, K15+, M2 and M5+). Only in K2 has a sensitive species been documented (*Navarretia fossalis*) in 1983 by Tim Cass. The Lower Otay Lake South pools are relatively undisturbed and contain only the sensitive species *Eryngium aristulatum*. The lack of disturbance suggests that protection and management rather than manipulation are appropriate. The Lower Otay Lake North pools contain a large amount of associated vernal pool habitat, but have only two pools with the sensitive species *Myosurus minimus* var. *apus* (both on K6) and relatively little invasion by exotic species. Restoration

possibly could expand the distribution of *Myosurus* on K6, and repair approximately five pools damaged by dirt roads (one on K6, about four on K10+). The K6 area has been designated a special study area on the General Development Plan - Subregional Plan Land Use Map. When a SPA/Specific Plan is submitted, additional analysis will be required.

RECOMMENDATIONS FOR PRESERVATION

Qualities that are important in determining which vernal pool areas should have highest priority for preservation (Table 10) include:

- Total vernal pool area;
- Concentration of rare vernal pool species;
- Historical occurrences of rare vernal pool species;
- Diversity of vernal pool and vernal pool fringe species; and
- Undisturbed nature of pools and mounded topography.

In addition, the ability to provide access to scientists while protecting sites from potential abuse is an important attribute. For management reasons, consolidating preserved sites is preferred over having several scattered preserved areas. Finally, the potential contribution of restored vernal pool areas should be considered in setting preservation priorities.

A summary of these important vernal pool attributes is presented in Table 10. Please refer back to Table 9 for restoration benefits.

The pool groups with the greatest vernal pool surface area are, in descending order: J 23-24, J 29-30, J 25, R 1, K 8, and K 1. Those that possess the state listed endangered *Eryngium aristulatum* var. *parishii* are J 29-30 (has the greatest abundance), J 23-24, J 25, J 31 South+, K 5, and R 3+. Those pool groups that possess the state listed endangered *Pogogyne nudiuscula* include J 25 (has the greatest abundance), J 23-24, and J 29-30. The only area that had *Navarretia fossalis* in 1990-1991 was a small part of J 29-30. The only mesa that had the rare species *Myosurus minimus* var. *apus* in 1990-1991 was K 6. Pool groups that have historical records of additional rare species are important for their value in supporting those species either through natural revegetation during years with more favorable climate or through restoration and reintroduction. Pool groups with important recent historical records (since 1978) include the western, disturbed portion of J 29-30 with *Myosurus minimus* var. *apus* and *Orcuttia californica* (not observed since 1979), J 31 South+ (Space Station) with *Navarretia* and *Myosurus* (not observed since 1979), and the R 1 area of Proctor Valley with *Myosurus* (not observed since 1978) and possibly *Navarretia*. Pool groups with the highest numbers of vernal pool species or with unique associations of species that typically occur on the fringe of vernal pools or in drier pool-like depressions include J 29-30, J 23-24, R 2+, and K 12+. The vernal

TABLE 10. SUMMARY OF IMPORTANT VERNAL POOL PRESERVATION ATTRIBUTES

Vernal Pool Group	Total Vernal Pool Surface Area (sq.ft.)	Rare Vernal Pool Species[1]	Additional Historical Occurrences[1]	Diversity of Vernal Pool & Fringe Species	Disturbance
Otay Mesa					
J 29-30	81,771	P, E, N, L	O, M	High	Low (portions)
J 31 South+	3,029	E	N, M	Low	High
J 31 North+	289	---	---	High	Low
J 23-24	104,995	P, E	---	High	Low (portions)
J 25	16,656	P, E	---	High	Low (portions)
Otay Valley					
J 32+	1,029	---	---	High	Low
K1	4,377	---	---	Moderate	Moderate
K15+	711	---	---	Low	High
K16+	187	---	---	Low	High
K2	0	---	N	Low	High
K17+	919	---	---	Low	High
Poggi Canyon					
M2	727	---	---	Moderate	High
M5+	157	---	---	Low	High
Lower Otay Lake South					
K5	2,546	E	---	High	Low
K10+	1,954	---	---	High	Low
K12+	726	---	---	High	Low
K13+	1,206	---	---	High	Low
K14+	346	---	---	High	Low

Table 10 (Continued)

Vernal Pool Group	Total Vernal Pool Surface Area (sq.ft.)	Rare Vernal Pool Species[1]	Additional Historical Occurrences[1]	Diversity of Vernal Pool & Fringe Species	Disturbance
Lower Otay Lake North					
K6	412	M	---	High	Low
K8+	5,581	---	---	High	Moderate
K9+	31	---	---	High	Low
Proctor Valley					
R1	14	---	M, N(?)	Low	High
R2+	7	---	---	High	Low
R3+	3	E	---	Low	High
R4+	1	---	---	High	Low

[1] = Vernal Pool Species Legend
P = *Pogogyne nudiuscula*
E = *Eryngium aristulatum* var. *parishii*
N = *Navarretia fossalis*
L = *Lepidium latipes*
O = *Orcuttia californica*
M = *Myosurus minimus* var. *apus*

pool groups with the least disturbed mounded topography include J 23-24, parts of J 29-30, J 25, R 2+, K 6, K 12+, and K 5.

Based on the above considerations (Table 10), we recommend that the following vernal pool groups be given first priority for preservation: J 23-24, J 25, and J 29-30 (Otay Mesa); K 6 and K 12+ (Lower Otay Lake area); and R 2+ (Proctor Valley) on the Baldwin property; R 1 and K 5 on property owned by the City of San Diego.

The Otay Mesa pool groups contain virtually all of the known species associated with vernal pools on Otay Ranch; what species they apparently now lack were present until rather recent times. It may be possible to reintroduce those species. The Otay Mesa pool groups also contain the vast bulk of both pool numbers, vernal pool surface area and restorable habitat. There are many acres of land that would be very difficult to restore J29, 30, 31, and also many acres that would be relatively easy to restore J23-25. The K6 mesa is recommended for conservation primarily for two reasons: it is the only known site on the Ranch for the very rare *Myosurus minimus* var. *apus*, and it has a large amount of relatively undisturbed mound topography associated with the few vernal pools. K12+ is recommended on the basis of undisturbed mound topography, presence of *Eryngium aristulatum* var. *parishii*, and high diversity of pool fringe species. The R2+ pools in Proctor Valley are included primarily for their undisturbed topography and low occurrence of weed, high species number, and unusual mix of fringe and pool species. The R1 pools are included primarily because of a large number of pools and two recent historic reports of rare species there: *Myosurus minimus* var. *apus* and *Navarretia fossalis* (the *Navarretia* report is of uncertain validity).

MANAGEMENT RECOMMENDATIONS

Neither simple dedication of vernal pool areas as open space nor enhancement/restoration activities will assure vernal pool preservation over the long term. Certain management activities must be undertaken to ensure long term viability. The most important features of management include resolution of ownership and establishment of funding mechanisms necessary for management. As described for the Preserve Manager in the Resource Management Plan, the vernal pool manager must have experience and capabilities including:

1. Biological resource expertise.
2. Prior experience coordinating scientific research and education.
3. Ability to coordinate monitoring efforts.
4. Ability to provide educational and interpretive programs and opportunities.

5. Ability to interact effectively with local and regional conservation agencies, recreational agencies, and the local community.
6. Demonstrated previous experience in long-term management of large open space areas with numerous sensitive species.

Actual management must be in conformance with an adopted management plan that includes recommendations and a tentative schedule for habitat restoration, removal of grazing animals, road closures, fence construction, signate, patrols and establishment of a public education program.

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APPENDIX A

FLORAL DATA WORKSHEETS

APPENDIX A

FLORAL DATA WORKSHEETS

Contents

KEY TO FLORAL DATA WORKSHEETS

Column Headings

Basin #: Those basin ID numbers that are bold-face correspond to basins that were identified as vernal pools.

Pg #: Raw data sheets were numbered chronologically from earliest to latest survey date.

Wetland veg/hyd: Indicates whether the criteria for hydrophytic vegetation and wetland hydrology were met for a given basin based on the Unified Federal Method for Wetland Determination.

Dimensions (feet): Major and minor axes of the vernal pool or basin habitat. Shape approximates an ellipse unless otherwise indicated; tri = triangle.

Dist.: See below for disturbance codes. A blank cell usually means that no significant disturbance was present (sometimes basins were not evaluated for disturbance).

Dominant Spp.: Plant species that made up 20 percent or more of the vegetative cover or collectively the most abundant species that exceeded 50 percent of the cover. Four letter species abbreviations are shown in Table 1 of the text. * Asterisk proceeding abbreviation indicates species has wetland status (Reed 1988).

Rare: Rare vernal pool species present in a given basin; rated according to the abundance codes listed below.

Vernal Pool Spp.: Plant species that occur within pool basins and are largely restricted to vernal pools according to Zedler (1987). Species in **bold-face** are considered by the authors to be indicators of vernal pools.

Other Wetland occur Spp.: Non-vernal pool species that are on the National List of Plant Species that in Wetlands: California (Reed 1988) as obligate wetland (OBL) facultative wetland (FACW), or facultative (FAC).

Disturbance Codes

u	-	undisturbed
c	-	cattle tracks
r	-	road
v	-	vehicle
s	-	scraping
b	-	bomb crater
g	-	grazed
go	-	gopher activity
e	-	ditching/excavation
d	-	discing
m	-	mowing
p	-	plowing
t	-	trash

Species Abundance Codes

d	-	dominant
c	-	common
u	-	uncommon
r	-	rare
x	-	present

APPENDIX B

SENSITIVE FAUNAL ELEMENTS OF THE VERNAL POOLS OF OTAY RANCH

Sensitive Faunal Elements of the Vernal Pools of Otay Ranch

A Report to: Michael Brandman and Associates

Prepared by: Biology Department
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Submitted: May 16, 1990

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As the vernal pools fill with water and the plant seeds begin to germinate, so too begin the life cycles of the faunal members of the pool systems. Crustaceans, insects, frogs and toads all are tied to this ephemeral resource.

Fairy Shrimp:

Of particular concern are the members of a group of crustaceans known as fairy shrimp (Order Anostraca). Fairy Shrimp are among the most characteristic inhabitants of vernal pools (1, 2), and where present they can be extremely abundant. Hatching as the pools fill with rain runoff, the shrimp develop quickly from larvae to reproductive adult in as little as a week (1). They can be seen in the pools swimming upside down as they filterfeed, using their numerous legs for both functions. Their graceful motion and frail appearance liken them to their namesakes, fairies.

Upon maturing, the shrimp quickly mate. Females may lay upwards of 200 eggs which settle into the bottom mud. The pond later dries but the eggs withstand desiccation and await the next rainy season. The eggs are very resistant. They may remain viable up to 15 years (3) and may be transported through birds' guts (4, 5), one method of colonization of new ponds (6). Species' distributions seem to be controlled by geographic and seasonal factors as they effect the temperature and water chemistry of pools (pH, chlorine, salinity, turbidity). Although some species are generalists in terms of their habitat preference, and quite widespread, for many, requirements for hatching the eggs and for the activity of adults are quite restrictive (4, 6, 7, 8, 9). For example, some hatch only at the low temperature of spring ice melt (<12°C) while others hatch

during the late spring (~17°C) or after summer rains. Fairy shrimp as a group, are prone to endemism (very limited distributions) (9).

California has the highest diversity of fairy shrimp of any area in the United States (40% of the total), probably due to the diversity of habitats available. Of the 17 species found here, six are endemic and four only recently described (9). The seasonality of their occurrence and the extremely restricted nature of their habitat has meant that in the past, they have often been overlooked. Now, with so much habitat lost to urbanization and agriculture, several are considered to warrant consideration as threatened or endangered (9).

The literature on species occurrence in San Diego vernal pools is extremely limited and incomplete at best (9, 10). Before last year, only one species, Branchinecta lindahli, had been documented on at least one mesa (10, 11). However, considering the diversity of the mesas, there was reason to believe that other species might be present. As most of San Diego's vernal pools have already been lost to development (12) and as some mitigation programs involved pool creation (13) and preserve design, The Nature Conservancy felt that it was essential that the composition of the mesas be surveyed.

In the summer of 1989 the Nature Conservancy granted the Biology Department at the University of San Diego, a small

Catherine Ordway Stewardship Award to begin a preliminary survey of the fairy shrimp of the mesas. In the first year spot checks were made of a few ponds on Otay Mesa, Del Mar Mesa, and NAS Miramar. In this extremely limited survey, three species of shrimp were found to be present. These were Branchinecta lindahli, Branchinecta sandiegensis, and Streptocephalus woottoni.

Branchinecta lindahli is the most common fairy shrimp in California and is not endemic, being found in all states west of the Rockies. It is very tolerant and occurs in a wide range of pond conditions. It is an extremely fast developer and can be found in very small puddles (9) and disturbed habitats (2). This species is probably not threatened at this time (9).

Branchinecta sandiegensis is a newly discovered species and is currently being described (M. Fugate [U.C. Riverside] pers. comm.). This species is seemingly a cool weather hatcher and shows up after winter rains. There have as yet been no detailed studies of its physiological requirements or population structure. To date, this species has only been found on the San Diego Mesa complex (personal observation), including Tecate, Mexico (M. Fugate, personal communication). Because of this narrow endemism, U.S. Fish and Wildlife has been petitioned to list it as endangered.

Streptocephalus woottoni - "The Riverside Fairy Shrimp" -

This newly described species seems to be a warm weather hatcher and does not necessarily appear with winter or early spring fillings (9). There have not yet been any detailed studies of its physiological requirements or population structure, but it does seem to occur in fairly large, deep pools (9). This species is the rarest fairy shrimp in California. It is known only from five pools in Riverside County (Skunk Hollow area) and two pools in San Diego County (Otay Ranch and NAS Miramar). The U.S. Department of Fish and Wildlife has been petitioned to list this species as endangered.

Michael Brandman and Associates requested that two Otay Ranch pool complexes (J25 and J30) be sampled for shrimp. Samples from a very few pools (live samples or hydration of mud from pools which did not fill naturally) revealed the following:

B. lindahli was not found to date on Otay Ranch, but could well be present.

B. sandiegensis was found in pool complexes J30 and J25.

S. B. woottoni was found in the J30 pool complex.

Considerations: Fairy shrimp population can be seriously impacted by a number of types of land use.

1.) Development obviously eliminates habitat. Most of San Diego's vernal pools are gone already (12). With the pools, go the shrimp. For those found nowhere else,

this means extinction.

2.) Chemicals such as pesticide in agricultural runoff may end up in pools and are considered to be a threat to shrimp populations (9).

3.) Modification of the watershed by both development and agriculture can change run-off patterns such that pools do not form, do not last long enough for shrimp to reproduce or do not last long enough into the warm season for warm weather species to hatch and complete their life cycle. This may eliminate some or all species from an area even though the pools may still exist. Modifications of watershed can also change the pool chemistry and in doing so could eliminate certain species (ex. the introduction of cement and asphalt can change soil chemistry). As the tolerance limits of the two new species are not yet known, this impact cannot be assessed at this time.

4.) Habitat fragmentation restricts gene flow and creates a threat to the genetic variability of any species and thus its continued existence (14). Development seriously fragments habitat. The population structure of these species is not known at this time. This information is needed before the severity of this impact can be fully assessed.

5.) If B. lindahli is found to be present, precaution must be taken not to let this "weed" species, which can exist in disturbed habitats, out-compete the narrow

endemics which have more restricted requirements and seem to require more pristine ponds. This could conceivably happen if pools are disturbed or if in the creation or enhancement of pools, improper innoculation is used.

6.) Off road vehicle use crushes eggs and destroys egg banks in the soil (15). The effects of the resulting turbidity vary with species. The limits for the species found on Otay Ranch are not known at this time; therefore the impact cannot be fully assessed.

Thus, other than the fact that two very narrow endemic species (possibly soon to be listed as endangered) exist on Otay Ranch, little else is know. There is an urgent need to quickly determine:

1. The distribution of the species (warm and cold hatchers) in all vernal pool systems in San Diego, particularly those slated for development such as Otay Ranch.
2. The physiological limits and optima, and the hatching and activity requirements of the two new species (temperature, water chemistry, etc.).
3. The genetic structure of the shrimp population (ex. levels of variability within ponds and extent of gene flow between ponds).

It is essential that this information be determined and utilized in any management, preserve or mitigation plans which consider the fairy shrimp.

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Spadefoot Toads:

Although they are amphibians, the spadefoot toads of the western states inhabit the driest of habitats. Spending most of the year burrowed in the soil, they enter water only long enough to breed (1). But not any water - only ephemeral waters such as vernal pools, desert playas, and cattle tanks. In these environments, the toads are faced with extremely harsh conditions and as such, their life cycle must be precisely timed to the existence of their very temporary aquatic habitats. In Southern California two species are found, Scaphiopus couchi in the desert and Scaphiopus hammondi in chaparral and grasslands (2).

Spadefoots exhibit what has been termed a xenic breeding pattern (3). The majority of the year is spent in burrows deep underground (20-90 cm) (4, 5). As the soil dries after the breeding season, they maintain equilibrium by concentrating urea in their tissues. In this way they can avoid lethal levels of water loss up to soil moisture tensions probably rarely achieved even in the desert (5). Spadefoots have no real breeding season but will emerge whenever the conditions are right (3). These conditions include rain and a temperature high enough to allow their activity. In many areas of the southwest spadefoots take advantage of the warm summer monsoons. In California however, where most of the rains occur in the winter, S. hammondi is cold adapted and breeds and develops successfully at cooler temperatures (6).

The toads emerge from their deep burrows quickly after the first heavy rainfall of the season (temperature allowing). The primary cue for their emergence is the sound of the rain and thunder, not the moisture. Unfortunately, the sound of a motor or water from a hose on the top of an aquarium will elicit up to 100% emergence (4,7) and motorcycle motors also work well (8).

Once up, the toads move to the ponds which form from the rain runoff, generally feeding on the way on the small arthropods (insects etc.) whose activity is also the result of storms. The males reach the ponds first, position themselves and begin to call. The females then arrive, enter the ponds and approach the calling males. When a female touches a male he clasps her around the middle (amplexus) and they swim together for awhile in the ponds (1 and personal observation). But these toads are what are called explosive breeders (9). Breeding congresses (ponds full of toads) are loud, often crowded, and usually restricted to a single night in any given area (1 and personal observation). Although a few males may call again the next night few females are present.

The eggs are laid that night; the female releases hundreds of them (10, 11) into the water in long strands or clumps often attached to vegetation. The male then releases his sperm over them and fertilization is external. By dawn all toads are gone from the ponds, having burrowed backwards (using the spade-like tubercles on their hind feet) a few centimeters into the moist

soil. The toads will now emerge from these shallow burrows for the next few evenings to feed (1). If a good flight of termites is available S. couchi males can potentially eat enough in one night to make it through the rest of the year, although females need two nights. Scaphiopus hammondi has a longer activity period however (12) and is not usually found where insects are so abundant.

The eggs hatch in just two days and the larvae are soon feeding. Temperature is important to anuran development and (13) California populations do well in cool temperatures. Spadefoot tadpoles are known for their fast development (10, 11, 14). They have to be fast. As with other amphibians of ephemeral waters, tadpole mortality can be quite high due to both predation and desiccation (14, 15, 16, 17, 18, 19, 20, 21) and these, along with competition are considered to be the strongest factors limiting such populations. Ponds may well dry before any or all tadpoles metamorphose and predators such as bullfrogs can completely wipe out the offspring of a year's breeding in a pond (10).

In the pond, tadpoles are omnivorous, eating plant matter, detritus, or other animals (1). They are especially fond of fairy shrimp, some of the many invertebrates with which they share the ponds (10). The genus, Spea, to which S. hammondii belongs is actually known to exhibit two larval morphologies, an omnivore (looking like a normal tadpole) and a carnivore (more

active with larger jaw muscles) (22, 23).

The time of metamorphosis is a dangerous period. The toadlets come out of the water and head for cover such as under a rock or in cracks in the soil. Here they resorb their tails, and their mouthparts change from tadpole to toad form. These toadlets will feed on cool, moist evenings to store reserves for their coming dormancy. As the winter goes on adults and toadlets alike will eventually retreat to deep burrows to await the next season.

The distribution of spadefoots tends to be under the control of soil types suitable for burrowing (1) and, of course, ephemeral ponds. In coastal San Diego, Scaphiopus hammondi is known to occur on the mesas where vernal pools are found (24, San Diego Natural History Museum records, and personal observation). Because of recent drought conditions, activity and breeding both in San Diego and Riverside Counties have been low. (Steve Morey [UC Riverside], personal communication, personal observation). In 1989, there was some successful reproduction in the Salt Creek area of Otay Valley (Steve Montgomery, personal communication and Del Mar Mesa, personal observation). However, data are limited and no reasonable assessment of the overall health or density of Southern California populations is currently available.

Considerations: Spadefoot toads populations can be severely impacted by a number of types of land use.

1. Development obviously eliminates habitat. As this industry prefers flat land as on the San Diego mesas, the vernal pools essential to the toads' reproduction are disappearing (24) and the toads along with them.

2. Agriculture often includes the construction of areas which will hold water permanently. This allows amphibians which need permanent water and fish to be introduced. Spadefoots cannot reproduce successfully where large aquatic predators are present. Especially harmful, are the growing populations of non-native Bullfrogs (Rana catesbeiana). These predators have been important in eliminating Red-legged frogs (Rana aurora) from most of Southern California (25). They readily disperse from permanent ponds in the rainy season and are known to quickly wipe out spadefoot tadpoles in nearby temporary pools (personal observation).

3. Off-road vehicle activity has a dual effect. First, it compacts soils, making them unsuitable for burrowing, closing cracks, or entombing the dormant toads beneath. Second, the sounds of the loud engines of these vehicles can bring up toads at unsuitable times (8). Once up they need to feed and take in water to rehydrate quickly. If conditions are not right they will die.

4. Spraying of insecticides reduces the insect populations which comprise the food source of adults. Subsequent run-off into ponds can poison the fairy shrimp which the tadpoles eat as well as the tadpoles themselves.

5. With development comes fragmentation of habitat and/or

such that ponds do not form from runoff or do not persist long enough for tadpoles to metamorphose. Fragmentation can also separate the pools where toads breed from the areas where they burrow and become dormant. These two habitat needs are not necessarily adjacent to each other. This would make breeding impossible.

6. Fragmentation of habitat also restricts movement and thus gene flow. This results in decreased genetic variability which puts any species at risk (26). The population structure of these toads is not known at this time. Therefore the extent of this impact cannot be fully assessed.

7. All of these considerations are complicated by the recent drought. Although S. couchi has been known to go up to three years without breeding (27), each year increases mortality within the population, and increases the age of survivors. Although the life span of spadefoots is not known, it cannot be more than a few years and each dry season certainly takes its toll. Those that do manage to breed often waste their efforts leaving tadpoles in pools from which they will not emerge. (This happened in some pools on Del Mar Mesa this spring (personal observation).

Unfortunately, there is no non-destructive way to study the populations of these toads in a drought. If a good rainy season occurs, it should be taken advantage of. An assessment of the toads' distribution, population health, and genetic structure would be invaluable.

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Curriculum Vitae

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Postdoctoral Research, 1985, The Museum of Natural History, Los Angeles, California. Under the direction of Dr. John Wright, Curator of Herpetology

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1990 California Department of Parks and Recreation Grant

Publications:

Simovich, M.A. 1978. Postfire reptile succession. M.S. Thesis. California State Polytechnic University, Pomona.

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Abstracts:

Simovich, M.A., (1984) Dynamics of hybridization in spadefoot toads. Amer. Zool. 24:80A.

Genetic identification of spadefoot toads involved in a hybridization system for the analysis of parasite species specificity and parasite life cycle strategy in ephemeral environments. Consulting with Dr. Richard Tinsley, University of London, England.

Research Interests: The use of biochemical and molecular genetic techniques for the continued investigation of: differential selection in multiple species reproductive interactions, the development of isolation mechanisms, hybrid zone dynamics, the role of hybridization in the process of speciation and the role of sexual system in speciation and taxonomic affinities within species complexes. Population genetics of vernal pool organisms with emphasis on conservation and management considerations.

Volunteer Work:

The Nature Conservancy: Santa Rosa Pleateau Reserve:

1. Consulting on Management of Fairy Shrimp and Spadefoot Toads of Vernal Pools, Santa Rosa Plateau.
2. Invited Speaker, Natural History Workshop.
3. Nature Walks Involved in Environmental Education Programs.
4. Consulting on Management Techniques for Vertebrates in Pre- and Post-fire Systems.

The California Department of Parks & Recreation:

1. Consulting on Vernal Pool Organisms, Hidden Lake, Mt. San Jacinto.
2. Tadpole shrimp survey of playas and tenajas. Anza Borrego State Park.
3. Small vertebrate survey; reassessment of old study sites (Banks, 1964). Anza Borrego State Park.
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Department of Biology, California State Polytechnic University, Pomona, 1976 through 1978.
Department of Biology, University of California, Riverside, 1978 through 1982.

Teaching: One Quarter as Lecturer in Vertebrate Zoology, 1977. California State Polytechnic University, Pomona.

Laboratory Experience: Eight years of electrophoretic analysis on spadefoot toads, also tadpole shrimp, fairy shrimp, numerous species of intertidal fishes, Little Blue Butterflies, and several species of Iguanid and Teiid lizards.

Currently using recombinant DNA technology including, restriction mapping, southern hybridization, nick translation, and development of hybridization probes.

Other Experience: Analysis of impact of Coachella Valley Wasteway Canals on vertebrates. California Dept. of Fish and Game, with Dr. Glenn Stewart.

Analysis of use of tree snags by reptiles. U.S. Forest Service.

Legless Lizard Survey. Silver Strand State Beach. California Dept. of Parks and Recreation.

3/26/92

Steve,

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of J29-30 is because that is the
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area that coincides with the presen
He agreed that the area heavily disturbed
would
storati

Floral data worksheets + hydrology data worksheets are not included

Good area for more intrusive restoration

Fig 17

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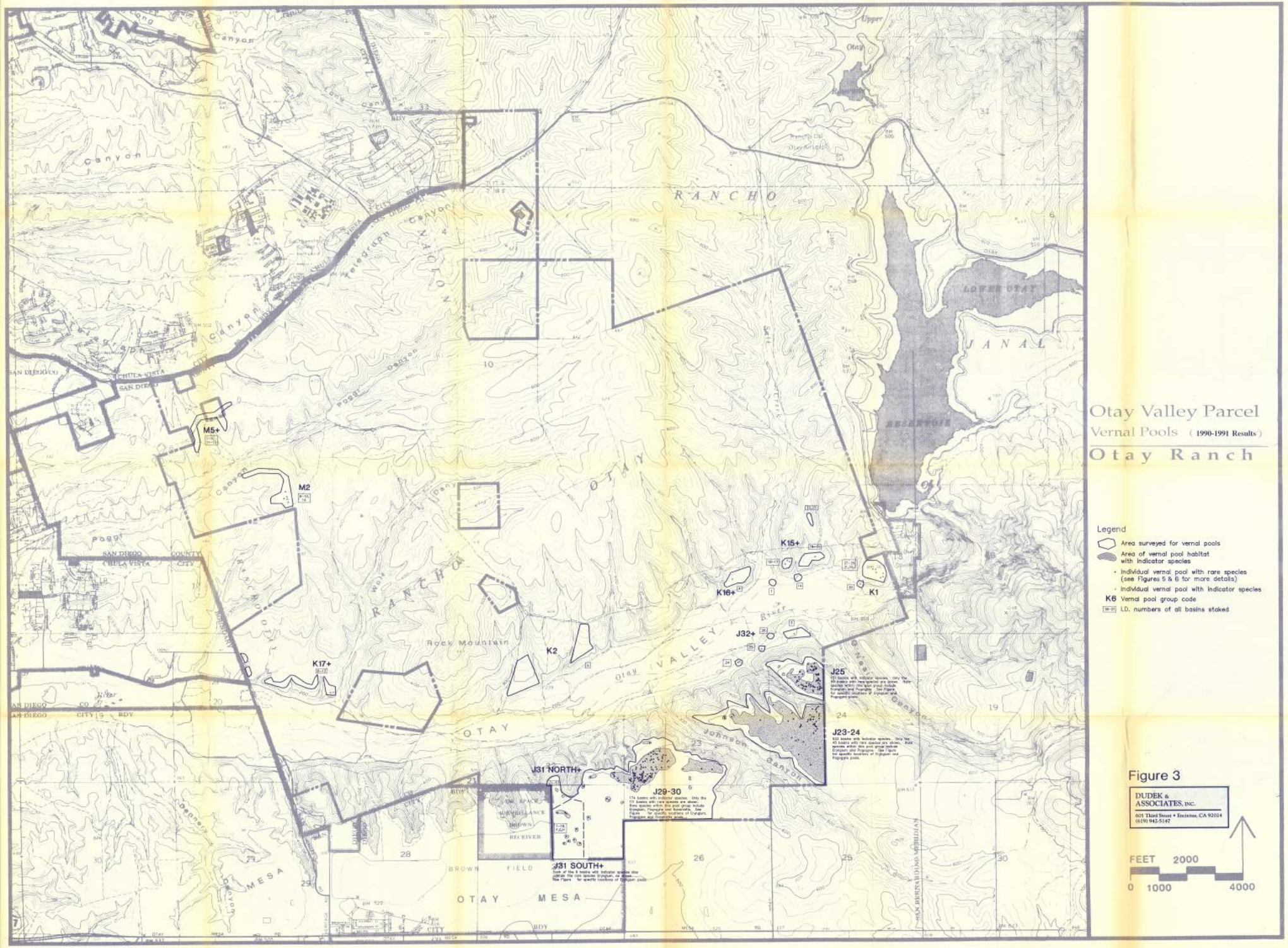
grazing at the appropriate
been used to help restore the Stipa

p.24 What was 1991 rainfall

p.25 Misleading to combine 1990 & '91 data because only a small sample of pools was surveyed on J29-30 in '91. Basins without pool spp. in '90 were not surveyed except in southern portion.

Not much potential for restoration here. This is undisturbed topographically & restoration would be very minimal (ie. removal of cattle)

(Source area ...
habitat is because it would be less costly to restore).


M5+
M2
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J32+
J25
J23-24
J31 NORTH+
J29-30
J31 SOUTH+
RANCHO
OTAY
MESA
Rock Mountain
Otay Valley Parcel
Vernal Pools (1990-1991 Results)
Otay Ranch
Legend
Area surveyed for vernal pools
Area of vernal pool habitat with indicator species
Individual vernal pool with rare species (see Figures 5 & 6 for more details)
Individual vernal pool with indicator species
K6 Vernal pool group code
L.D. numbers of all basins staked
Figure 3
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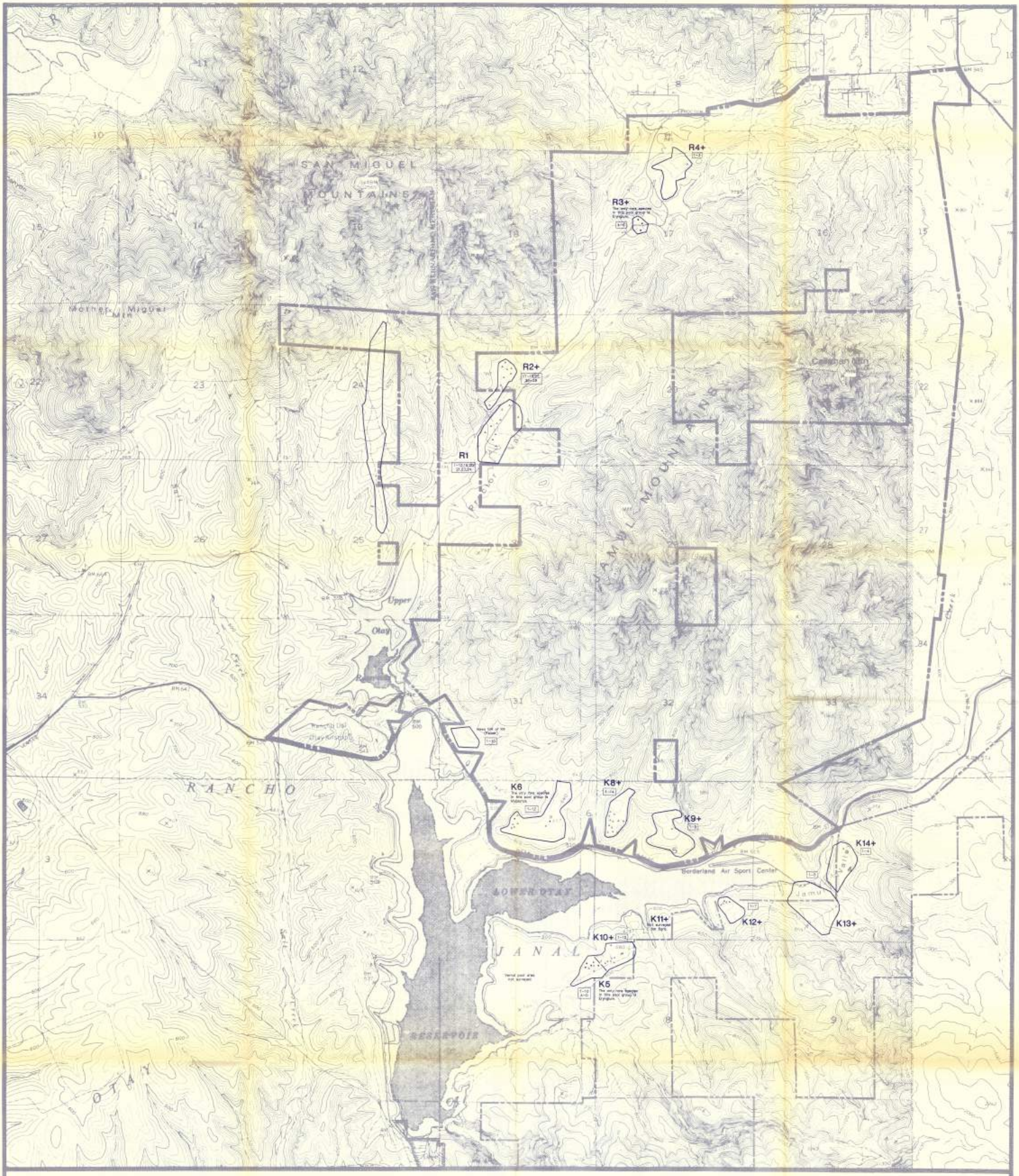

Legend

- Area surveyed for vernal pools
- + Individual vernal pool with rare species
- + Individual vernal pool with indicator species
- K6 Vernal pool group code
- 1-3 I.D. numbers of all basins staked

Figure 4

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Proctor Valley/ San Ysidro Mountains Parcels Vernal Pools (1990-1991 Results)

Otay Ranch